Rice Production, Income Diversification and Rural Development in Myanmar

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Declaration

I, Nilar Aung, declare that this thesis entitled, 'Rice production, Income diversification and Rural Development in Myanmar' and the work presented in it are my own work, except where specific reference is made to the work of others. This thesis has not been submitted for the award of any other degree or qualification at any other university. I confirm that Parts of Chapter 3 have been accepted for publication with my thesis supervisor and advisor as Aung N., H.T.M. Nguyen, and R. Sparrow (forthcoming). 'The impact of credit policy on rice production in Myanmar' Journal of Agricultural Economics. In this work, I collected farm data and I was instrumental in the data analysis and estimations for most of other results. I also contributed to the literature review. In terms of exposition, I made substantive contributions to all sections of the paper.

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Abstract

Among agricultural produce, rice is still dominating the Myanmar's agriculture sector, as it is a staple food crop and a principal export crop. Although previous market reforms and major investment in the agriculture sector have led to an increase in rice production, there have been challenges, such as limited availability of loans, poor infrastructure, application of farm inputs and the quality of seeds. My thesis comprises three essays that, together, fill the gaps in the existing literature on most of the key issues affect rural development in Myanmar.

The first essay analyses the source and extent of potential productivity and efficiency gains, and investigates how Myanmar can increase its rice productivity. The data used in this thesis is taken from 634 farm households in the main rice growing regions, specifically Ayeyarwaddy, Bago and Sagaing. The stochastic production frontier and technical inefficiency models are applied to capture which farm-specific factors determine efficiency gains. The findings show that rice production in the selected regions can be improved through farm workers with better education, agricultural extension services, and efficient fertilizer and pesticide application.

This essay also analyses the impact of land reforms and market reforms on rice production in Myanmar and Vietnam. Although there are differences between the two countries, especially in terms of government policy and institutions, both share some similarities when it comes to rice production. Vietnam is a more efficient rice producer than Myanmar, due to its better irrigation system, use of better quality seeds, higher application rate of fertilizers, and more intensive cropping. There may be many lessons for Myanmar to learn Vietnam's to increase the quantity and quality of its rice production by applying certified seeds and efficient use of fertilizers, and using sufficient irrigated water.

The second essay examines the impact of credit policy on rice production in the selected regions. The provision of agricultural credit is used as a major

tool to develop rural areas and reduce poverty in Myanmar. Despite the rapid expansion of agricultural credit by the Myanmar Agricultural Development Bank (MADB), there are some limitations on applying for credits, such as the credit amount per acre and the landholding size. A fuzzy regression discontinuity design approach is applied to identify the effects of agricultural credit, making use of the MADB's credit rule based on landholding size up to 10 acres. Although the subsidized credit scheme shows little impact on rice output and rice income, the credit program has some positive effects on total household income, suggesting a positive spillover effect on other farm income activities.

The third essay assesses the determinants of income diversification from different sources and its impact upon the rural economy of Myanmar. Despite the fact that rice production still plays a major role in the rural economy, the diversity of income from both agricultural and non-agricultural activities has been part of an important strategy for rural livelihoods among farm households since the late 1980s. This essay analyses the factors determining income diversification from different sources on rural households' income and their contribution to income inequality amongst farm households. The findings show that household's demographic characteristics, total land size, ownership of assets are the main factors leading towards income diversification. The results of the decomposition of Gini coefficient indicate that aggregate income from non-rice crops, especially pulses and beans, helps to significantly reduce income inequality among farm households in the Bago and Sagaing Regions. Overall, the results reveal that the cropping patterns for producing rice and different type of pulses and beans, as well as participation in livestock farming, are the most important factors in decreasing income inequality.

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Chapter 1

Introduction

After decades of isolation, Myanmar has begun opening up and re-engaging with the regional and global economy since 2011. While much of the economic investment has been initiated in areas such as mining, telecommunication, gems and tourism, interest in the development potential of the agricultural sector has been growing in Myanmar. In fact, agricultural growth has played a crucial role in economic growth and poverty reduction in Southeast Asian countries, such as Thailand, Vietnam, Indonesia and Malaysia, all of which have had the experience of successful development in the agricultural sector (Christiaensen et al., 2011). Agriculture in Myanmar, including livestock, fisheries and forestry, accounts for roughly 43 per cent of GDP, and employs nearly 70 per cent of the labour force (Haggblade et al., 2013). Due to its abundant natural resources (land and water) and large labour force, agricultural growth in Myanmar could be a major driver of economic growth and rural incomes. For example, the average farm size in Myanmar is 2.57 hectare, which is the second largest among the Southeast Asian countries after Thailand. The government of Myanmar has given attention to the development of the agriculture sector, which is one of the 'seven key pillars supporting and enabling inclusive and sustained economic growth' (Ministry of Agricultural and Irrigation, 2015, p.1).

Among agricultural produce, rice is still dominating the Myanmar's agricultural sector, as it is a staple food crop of the people of Myanmar and a principal export crop. Myanmar's economy has been primarily dominated by a monoculture rice crop. Rice production employs nearly 61 per cent of the rural workforce and it contributes 75 per cent of rural income (Wong and Wai, 2013). Rice production contributed 40 per cent of the gross agricultural product and 13 per cent of GDP in 2013-2014 (KPMG, 2015). The development of the rice sector is expected to contribute to 'building a progressive agriculture sector that will propel economic development in other sectors and eventually transform Myanmar into a modern, industrialized nation' (Ministry of Agricultural and Irrigation, 2015, p.1). Increasing productivity in rice could help improve the livelihoods of rural farm households. The Ministry of Agriculture and Irrigation (MOAI)[1] is increasingly investing in the development of the rice sector to promote agricultural productivity. Given the importance of rice production, previous Myanmar governments have implemented various policies and reforms during the last century that have affected rice production.

1.1 Background to Myanmar's agricultural policy

Until the early 1960s, Myanmar was the world's largest rice-exporting country, accounting for nearly 75 per cent of the world's rice exports (Young et al., 1998). However, Myanmar has fallen from being a major rice exporter to being a self-sufficient rice producer since the adoption of the socialist system in 1962 (Soe and Fisher, 1990). Previous literature has analysed government policies and other factors that affect rice production. These factors include the land policy, the procurement system and price policies, agricultural credits, and research and extension services.

The socialist government (1974-1988) launched its land policy in 1974. Under this policy, the state owned all natural resources and all land. Farmers had tillage rights that had to be renewed annually. Farmers were prohibited from selling or transferring their land rights or changing agricultural land use. Each farm household could have a maximum of 50 acres (approximately 21 hectares). Importantly, the government introduced a marketing policy in 1974-1975, which included a compulsory delivery quota system at fixed prices for all major crops. Farmers were required to deliver between 10 to 12 per cent of their produce to the government at fixed prices, which was half of the free market prices. The quota amount was based on the sown area and its yield (Soe and Fisher, 1990). These two policies discouraged farmers from improving their land productivity and rice yields. Rice production significantly declined during this period.

[1] The Ministry of Agriculture and Irrigation was restructured as the Ministry of Agriculture, Livestock and Irrigation (MOALI) in 2016.

In the mid-1970s, the government introduced the 'Green Revolution' using advanced technology, high yielding variety seeds (HYV) and subsidized chemical fertilizer to increase rice production. This program was initially trialled in a township in Lower Myanmar in 1975, and was expanded in the Whole Township Rice Production Program (WTPPP) in 1978-1979. In this program, agricultural extension services, which were introduced in 1927 (Cho, 2013), played an important role in the distribution of HYV seeds and fertilizers and in provision of technical assistant to farmers. Under this program, rice production significantly increased between 1975 and 1985 at a 6.35 per cent annual growth rate, mainly as a result of an increase in the rice yield per acre. In 1987, the government implemented its first agricultural reform. Under this reform, the government reduced the amount of crops that farmers had to deliver and lifted restrictions on the export of some agricultural products, such as black gram, green gram, maize and pigeon pea. Rice, however, remained under state control. Subsidies on chemical inputs including fertilizer, seeds and pesticide were gradually transferred to the private sector.

In 1988, the State Law and Order Restoration Council (SLORC) government came to power. One of the economic objectives of the SLORC was the 'Development of agriculture as a base and all-round development of other sectors of the economy as well' (Thein, 2004). In 1992-1993, the government introduced the summer paddy program (SPP) and expanded the area devoted to rice and improved irrigation facilities to further increase rice production, which resulted in a significant increase in rice production during this period. In 1997, to further develop the agricultural sector, the SLORC government reformed the Myanmar Agricultural Development Bank (MADB), a state agency that provides agricultural credit. The MADB provides three types of agricultural loan, namely, seasonal loans, term loans and area development loans to farmers. Although there are other formal and informal financial institutions in the rural credit market, farm households rely heavily on loans from the MADB as it offers the lowest interest rate compared to that of other financial institutions. The MADB has been increasing the amount of credit for rice cultivation since 2008. The MADB provides 100,000 Kyat per acre for seasonal loans at a maximum of 10 acres.

The SLORC government invested heavily in irrigation projects. The Irrigation Department under the Ministry of Agriculture and Irrigation constructed 108 irrigation projects, including dams and reservoirs, between 1988 and 1999. The irrigated sown area was 41,921 acres in 1990. As a result of dam irrigation projects, the irrigated sown area increased to 119,400 in 1999 (Thein, 2004). In 2003, the SLORC government launched its second agricultural reform and finally abolished the delivery quota system. Although agricultural land was still under state control, farmers could choose their crops and agricultural activities. In 2006, the Ministry of Agriculture and Irrigation established the Myanmar Agricultural Service (MAS). The Agricultural Extension Division (AED) under the MAS is responsible for training and extension services. In 1998-1999, rice production in Myanmar was 17.08 million metric ton. After the introduction of agricultural reform in 2003, rice production significantly increased from 21.81 million metric ton in 2003 to 28.32 million metric ton in 2014 (Department of Agricultural Planning, 2014b).

Since 2011, Myanmar has been engaged in a process of political and economic liberalization that helps improve the country's economy development. In 2011, a political reform was launched in Myanmar and an elected government came to power. The FAO (2012) reported that 'To support the rural development and poverty reduction activities through development of agriculture' is one of the National Economic and Social Development objectives (2011/2012-2015/16) (FAO, 2012). In March 2012, the government launched a new land law, namely, the Farmland Law, Rule, and the Vacant Fallow and Virgin Management Law (2012). Under this law, farmers can sell, transfer and mortgage land use rights, although the state still owns all land. The most important feature of this law is that land use rights now have an indefinite duration. Farmers can use their land so long as they do not breach government conditions. The law also encourages investment by rural co-operative associations and/or the private sector for land development.

In 2015, Myanmar held another election, following which the National League for Democracy (NLD) party formed government. The NLD government also gave priority to the development of agricultural sector. In 2016, the government restructured the Ministry of Agriculture, Livestock and Irrigation (MOALI) by merging the previous three Ministries (Agriculture and Irrigation, Livestock Fisheries and Rural Development and Cooperatives), aiming to ensure food and nutrition security, increase foreign exchange earnings and contribute to rural development. In the same year, the amount of credit was increased from 100,000 Kyat (USD 100) per acre to 150,000 Kyat (USD 150) per acre for rice production. Remarkably, the NLD government focuses on the diversification of income and the development of the rural non-farm sector, which are key elements in the process of the agricultural transformation of

Myanmar.

1.2 Current perspectives on the agricultural sector

Although previous markets reforms and major investment in the rice production sector have led to an increase in rice production, there has been just a little improvement in the development of the rice sector in Myanmar. Challenges include the limited availability of loans and limited access for farmers to technology, less efficient agricultural extension services, the improvement of seed quality, application of farm inputs and low development of rural infrastructure (particularly for rural roads, irrigation facilities and power). The average rice yield in Myanmar is roughly 3.84 tons per hectare at the national level, which is the second-lowest among the Southeast Asian countries (Raitzer et al., 2015). In addition, the return on paddy cultivation tends to be low and this affects farm household incomes.

Consequently, other non-rice crop production, other farming activities and non-farm activities will all be part of a farm household's decision-making process. In more recent times, Myanmar has become one of the major exporters of pulses and beans. Pulses and beans are increasingly important crops in Myanmar, and now are the second-most important crops after rice. Pulse production increased by 9 per cent per annum after the SLORC government's first reform in 1987 had allowed free trade in these crops. Exports of major pulses (green gram, black gram, pigeon pea, cow bean, kidney bean and soya bean) rose by 17 per cent per annum, comprising 60 to 70 per cent of agricultural exports in the early 1990s (Okamoto, 2008). Pulses are currently Myanmar's largest agriculture export item, accounting for $1,152 million in 2015-2016 (MOALI, 2018). Myanmar becomes now the world's second-largest exporter of pulses and beans.

Pulses and beans are grown in many parts of Myanmar. The main producing area is the Central Dry Zone, followed by the Delta Region, Hilly Region and Coastal Zones (Raitzer et al., 2015). Farmers have more incentive to produce pulses because they can plant them after paddy to benefit from the moist soil after the rice harvest, and pulses have lower production costs, need less water, and are rising prices compared to rice. Aside from rice, pulses and beans, and other crops (such as sesame, groundnut and oilseeds) also play an important role. However, successive governments have provided more support for rice production than for other crops. For example, the amount of loans provided by the MADB for crops is relatively low compared to that of loans for rice production. The government of Myanmar (GOM) has heavily invested in irrigation: rice is grown in approximately 76 per cent of the total irrigated area. The type and level of government support, such as irrigation services and policies, places limits on which crops farmers can plant, and become important factors for farmers in making decisions on household livelihoods, and on rural income inequality. However, the literature on the contribution of rice and non-rice crop income to income inequality in Myanmar is limited.

1.3 Thesis outline

My thesis comprises three essays that, together, seek to fill the gaps in the existing literature on most of the key issues that affect rural development in Myanmar, with a main focus on rice production, followed by non-rice crop production. Given the absolute and relative importance of rice in Myanmar's rural economy, the first essay analyses productivity, efficiency and rural development in Myanmar's rice production. The objective is to examine how Myanmar can further increase its rice productivity; this essay analyses the source and extent of potential efficiency gains. A primary dataset, which is collected in the most rice growing regions, Ayeyarwaddy, Bago and Sagaing is used in this thesis. The total number of farm household in this study is 634 across 30 villages.

Myanmar has a substantial potential to further develop rice production, due to its abundant natural resources including water and arable land, and available labour force with the lowest minimum wage in the region. This first essay, therefore, applies stochastic production frontier and technical inefficiency models to capture which farm-specific factors determine efficiency gains. There are many ways in which farm productivity can be improved by measures such as training, lower transportation costs, provision of credit and land fragmentation.

Literacy of household members who are currently working in agricultural activities is also important in improving rice productivity as it can allow farmers to easily understand the application of fertilizers, pesticides and other techniques. The majority of farm workers in Myanmar are not well-educated, and they do not know how to use chemical inputs and new technologies systematically. This chapter also discusses the relationship between the education level of household farm workers and rice production. In this case, the provision of education and training is found to be one of the important factors in assisting farmers with technical knowledge to improve rice production.

Better roads can boost rice and non-rice crop productivity by lowering transportation costs for agricultural inputs and outputs. However, the transportation system in Myanmar is one of the poorest of all ASEAN countries (ADB, 2012). In this first essay, the distance from a village to a market nearby a township is used to estimate the importance of access to better roads and transportation in rice production and other business activities. To fill the gaps in the previous literature, the first essay adds these variables to estimate their effect on rice production efficiency.

The MADB has been increasing its seasonal loans; however, the amount of credit per acre can cover about 20 per cent of production cost per acre. As a matter of fact, land use certificates (LUC) could not be used as collateral for borrowing loans until 2012. Due to the lack of collateral and the high risk of default, informal sectors usually charge at very high interest rates. This chapter analyses the availability of loans from both the MADB and the informal sector and their effect on rice production.

Although land fragmentation in Myanmar has not previously been a significant constraint on rural productivity, the number of plots per household is increasing. The first essay estimates the effect of land fragmentation by holding land size and number of plots for each farm. Several studies have examined factors that determine the productivity and efficiency of Myanmar rice production; however, none of them have investigated the impact of credit and land fragmentation.

The second part of this essay analyses the impact of land reforms and market reforms on rice production in Myanmar and Vietnam. Vietnam was chosen as a comparison because two countries share some similarities when it comes to rice production. However, the trajectories of rice production in two countries are in marked contrast, especially in terms of government policies and institutions. Vietnam has achieved a remarkable increase in rice production due to land reform and trade liberalization in 1988. Land reform in Myanmar has lagged behind Vietnam by more than 20 years. Unfortunately, this review fails to conclusively examine the effect of land reform on Myanmar's rice production, as the Myanmar government was in the process of replacing farmers' old single-year land use certificates with new, unlimited duration ones during my fieldwork. Vietnam's *DoiMoi* reform took place one year earlier than market reform in Myanmar. The agriculture sector employs 63 per cent of the labour force in Myanmar (FAO, 2016) that is relatively lower than that of Vietnam. Vietnam has been found to be more labour intensive compared to Myanmar as over 70 per cent of population is involved in the agricultural sector (Tran Toan Thang, 2014).

The other factor is the educational level of farmers. Myanmar 's farmers are lack of knowledge and less educated than other countries in the region. The literacy rate in rural area of Myanmar accounts for 84 per cent (Zorya, 2016). In contrast, the literacy rate in Vietnam 's rural area is 88.7 per cent. It is worthy to note that the definition of literacy used in Vietnam differs from the definition in other studies. The Government of Vietnam has introduced the first campaign of literacy in 1954 (Phan et al., 2004). A person is defined as literate when he or she has completed at least grade 5 (primary education from grade 1 to 5). In this case, farmers in Vietnam are found to have better educational achievement. Although both countries have similar land areas under rice cultivation, Myanmar has lagged behind Vietnam in terms of rice production. Vietnam's better performance is due to its better irrigation system, use of better quality-seed, the higher application rate of fertilizer, higher cropping intensity, more educated farmers and more labour intensive. Myanmar could increase its rice production by learning from Vietnam's experience.

The second essay examines the impact of credit policy on rice production. Although there are other formal and informal financial institutions in rural credit markets, farm households rely heavily on loans from the MADB, due to its low interest rate compared with that of micro finance institutions (MFI) and informal sectors. The MADB provides the agricultural loan at an interest rate of 8.5 per cent per annum (around 0.71 per cent per month). The other financial institutions, in particular, microfinance institutions (MFIs) operated by the Central Cooperative Society (CCS), PACT UNDP, World Vision and Save the Children charge an interest rate of 2.5 per cent per month (30 per cent per annum). An informal sector consists of money lenders, relatives, and friends. Most of the money lenders charge at 10 to 20 per cent per month, while friends and relatives charge various interest rates. The semi-formal sector is composed of pawnshops, village revolving funds, and village savings and credit groups. The interest rate charged by pawnshops is 3 to 5 per cent per month, but they deal in gold as a collateral (Duflos et al., 2013).

The MADB's financial constraints limit its maximum loan to individual farmers to 1,000,000 Kyat [2] (USD 1000) for a maximum of 10 acres. This means that an average amount of credit per acre decreases with landholding size. The MADB mainly provides loans to small farm holders. Large farm households with holdings of more than 10 acres receive less credit per acre for rice production. The lack of sufficient agricultural credit is a major constraint on lower productivity. The literature on the effect of the MADB's credit policy on rice production in Myanmar is limited. In order to examine the credit policy and its impact on Myanmar's rice production, this essay uses the fuzzy regression discontinuity (FRD) approach, making use of the rule of providing credit based on rice landholding size up to 10 acres. This study analyses the full sample, sub-samples with holdings of land 0-20, 5-15 and 8-12 acres to estimate the effects of credit amount per acre on rice production, rice output per acre, rice income and total income by controlling household's demographic characteristics (age, educational level, gender of a household head, a number of family workers and dependency ratio), access to agricultural extension service, irrigation facilities and regional effects. The distance from a village to a township is used to estimate the relationship between rural infrastructure and access to credit. Farm households that live far from a township branch bank; have less incentive to apply for credit due to transportation costs.

The third essay focuses on income diversification and income inequality in the rural economy. This essay has two parts. The first part identifies the factors that constrain farm households from participating in different farming and non-farming activities. The inverse Herfindahl index is used to investigate the factors that lead farm households to diversify their production more towards pulses, beans and other non-rice crops, and to measure the degree of income diversification. This essay also examines the degree of diversification among the regions due to the different soil types of the regions. In this study, the soil type of the selected villages in Ayeyarwaddy region is appropriate for the cultivation of rice. In contrast, the soil type of Sagaing in the Central Dry Zone is more suitable for planting pulses and beans. Bago can produce both rice and non-rice crops, especially pulses and beans. Most farmers in Bago and Sagaing are engaged in the cropping pattern of rice and non-rice crops, while those in

[2] The exchange rate of 1 US Dollar was approximately 1000 Myanmar Kyat in 2014.

Ayeyarwaddy are involved in a mono-rice practice. The agriculture of Myanmar is still labour intensive [3]. Most farmers cannot use tractors, because they have limited finance for hiring tractors. This essay attempts to find out how the ownership of a tractor is attracting farm households to become involved in other business activities.

The second part examines household livelihood strategies, in which income sources contribute to income inequality amongst farm households. The Gini decomposition coefficient is used to measure income equality in the selected regions. Due to the different characteristics of geographical location, this essay analyses the Gini coefficient of each region, and examines the contribution of each income source to income inequality among farm households. The comparative advantage of each region is expected to suggest business activities that help increase a farm household's income in the selected areas.

The conclusion section summarises the key findings of this research related to the research questions of each essay. This section identifies the implications of the findings to increase rural income through improved rice productivity, non-rice crop production and livestock production. This section also outlines the limitations of this research that should be considered for further study.

[3] Approximately 16 per cent of farm households across the country use mechanized tractors or tillers (Raitzer et al., 2015).

Chapter 2

Productivity, efficiency and rural development in Myanmar rice production

2.1 Introduction

Myanmar has a traditional agricultural economy based on rice production. Rice is the dominant crop in the agriculture sector due to its being a staple food of the people of Myanmar and a major export commodity. Myanmar is the world's sixth-largest rice-exporting country. Rice production contributed nearly 80 per cent to the total value of agricultural produce in 2010 (ADB, 2013). Moreover, 75 per cent of people living in rural areas are primarily engaged in the agriculture sector. Rice production employs the highest percentage of workers accounting for 61 per cent of the total labour force in rural areas (Kyaw, 2009). Rice production, therefore, still plays an important role in Myanmar's economy.

As Myanmar grows more rice than it consumes, the surplus in rice production helps ensure national food security. The food security of the country is generally achieved by self-sufficiency at the national level (Shwe and Hlaing, 2011). However, like many other developing countries, Myanmar's growing population is increasingly challenging its food security goals: the population is growing at an average annual growth rate of 1.1 per cent (Agricultural Extension Division, 2013). This growing population is increasing the domestic consumption of rice (Kubo et al., 2004). It also places increasing pressure on available land, meaning that increasing rice production will rely on raising productivity (Sawaneh et al., 2013).

Given the importance of rice production, the Government of Myanmar implemented two agricultural reforms in 1987 and 2003 to move from a socialist economy to a market-oriented economy (Okamoto, 2005). The government also promoted producing more rice by introducing a summer paddy production program (SPP) in 1992, which expanded land and irrigation facilities (Department of Agricultural Planning, 2012). Although these efforts significantly increased total rice production, the average yield of rice paddy has remained at 3.1 tons per hectare since 1995 (Denning et al., 2013). A major reason for this low level of paddy yield is the removal of subsidies on farm inputs, especially fertilizer, under the first reform (Aung, 2011). However, Myanmar still has the potential to increase paddy yield by providing sufficient agricultural loans, applying modern technology, improving irrigation systems and further developing infrastructure.

In an effort to analyse efficiency in rice production, previous empirical studies (Aung, 2011; Myint and Kyi, 2005; Naing et al., 2008; Nan Wutyi et al., 2013) investigated a number of factors that impact upon the efficiency of Myanmar's rice production. These studies have shown the effects of the age of the household head, the number of years of farming experience and the educational level of this household head, access to agriculture extension services on rice productivity, and the application of low level of fertilizer in rice production. However, these studies have not observed the impact of the amount of available loans on productivity. Further, previous studies have not analysed the combination of farm size and number of plots, nor examined the effect of distance from villages to market and infrastructure development in rural areas.

Therefore, the specific objective of this research is to analyse the productivity and efficiency of rice production of the selected Myanmar farm households in the most productive rice growing regions, specifically, Ayeyarwaddy, Bago and Sagaing. The data used in this research was taken from author-collected farm survey data from 634 farms across 30 villages, in these regions. This paper aims to fill the gaps in the literature by adding new variables of interest in the rice production sector. The stochastic production frontier model is applied to determine the source and extent of potential productivity and efficiency gains and determine the factors that influence the efficiency of rice production. Identifying these factors will give us insights into the effectiveness of the government's policy and strategies for improving the rice production sector. This, in turn, will promote the rural economy and reduce poverty, as rice is the main source of rural income.

The rest of this essay is organised into seven sections. Section 2.2 explains the background to rice production in Myanmar and agricultural market reforms. Section 2.3 discusses the literature review. The data source and variables are described in Section 2.4. Section 2.5 examines the methodology of the stochastic production frontier model and the technical inefficiency model to estimate the potential effects on rice production. The result of data set is discussed in Section 2.6. The findings of research and some recommendations are included in Section 2.7. The analysis of rice production between Myanmar and Vietnam is analysed in Section 2.8 of Appendix.

2.2 Background to Myanmar's agriculture

2.2.1 Rice production in Myanmar

Myanmar enjoys many natural resources including agricultural land, abundant water resources and a favourable climate, all of which are suited to rice production. The production of paddy accounts for 57 per cent of major crop production, in particular, 26 crops reported as major crops in 2012 (Department of Agricultural Planning, 2012). The cultivable land area for rice makes up 34 per cent of the country's total sown area in 2011-2012 (Agricultural Extension Division, 2013). Although rice is planted throughout the country, the major rice growing regions are Ayeyarwaddy, Bago and Sagaing. The Ayeyarwaddy and Bago Regions are located in the Delta Region whereas Sagaing is located in the Central Dry Zone. Monsoon paddy is usually rain-fed in Ayeyarwaddy and Bago while it is grown under irrigation in Sagaing (Agricultural Extension Division, 2013; Department of Agricultural Planning, 2012). Ayeyarwaddy, Bago and Sagaing respectively account for 27 per cent, 17 per cent and 10 per cent of the Myanmar's total cultivated land, and 26 per cent, 17 per cent and 12 per cent of total rice production (Agricultural Extension Division, 2013).

During the British Colonial Government period (1885-1948), rice was only cultivated in the monsoon season. However, farmers in Upper Myanmar cultivated pulses and beans, followed by rice, when irrigated water was available in the summer season (Win, 1991). In order to increase rice production, the Department of Agriculture was established in 1906. An expansion of the land under rice cultivation increased production dramatically. Myanmar became the world's largest rice exporter and rice became the most important crop in the development of the country's economy (Oo and Kudo, 2003).

After independence in 1948, the parliamentary government (1948-1961) implemented the Agricultural and Rural Development Five-Year Plan. Under this plan, the government introduced advanced technology, promoted intensive cropping, and land reclamation and distribution. The government supported fertilizer, mechanization and irrigation facilities. However, investment in the agriculture sector accounted for only 9 per cent of total expenditure between 1952-1953 and 1959-1960 (Thein, 2004). Although rice production had been gradually increasing since the early 1940s, the growth of rice production was relatively small until 1957 (Win, 1991). Under the Revolutionary Council Government (1962-1973), the average growth rate of rice production was 1 per cent, lower than the population growth rate of 2.2 per cent. This showed a need to increase rice productivity to ensure food sufficiency. With the objective of rice self-sufficiency, the government implemented high yield variety (HYV) seeds with fertilizer, and new technology in 1966 and 1967 (Oo and Kudo, 2003).

The socialist government (1974-1988) introduced the Whole Township Paddy Production Program (WTPPP) in two townships to promote increased rice yield in 1977-1978. The program was extended to another 82 townships (of a total of 314 townships) in 1985-1986. Under this framework, the government mainly provided chemical fertilizer at a subsidized price to rice farmers in the programme areas. The total sown acreage of these townships accounted for 52 per cent of the country's total sown acreage of rice. Total rice production over this period was more than 10 million tons (Win, 1991). Myanmar enjoyed the surplus of rice with a 6.35 per cent average growth rate of rice compared to a 2 per cent population growth rate during this period (1974 to 1985) (Thein, 2004). In 1992-1993, the government introduced the Summer Paddy Program (SPP) through the subsidies of chemical fertilizer and diesel fuel for pump irrigation. Due to the SPP program, the sown areas of rice in Myanmar rose from 5.13 million hectare in 1992-1993 to 6.45 million hectare in 2001-2002 (Oo and Kudo, 2003).

In 1999-2000, rice production was 19.8 million tons, a remarkable yearly growth rate of 16.5 per cent (Thein, 2004), 80 per cent of which was monsoon paddy and 20 per cent summer paddy (Oo and Kudo, 2003). In 2013-2014, the cultivable land area for rice increased to 7.28 million hectare (Agricultural Extension Division, 2013). The expansion of land, the provision of irrigation facilities and the introduction of the SPP were the main factors explaining this increase. Although there has been a significant increase in the amount of rice produced in Myanmar, the average yield per acre has not changed significantly since 1995.

Moreover, the growth rate of yield per acre has been slower than the expansion rate of the harvested area. This is known as 'horizontal expansion' in a dynamic rice sector, when a country increases significantly its total output by expanding available land for cultivation (Aung, 2011). The average yield per acre was approximately 2.8 ton per hectare for monsoon and 3 ton per hectare for summer paddy, with an annual growth rate of rice production of approximately 1 per cent since 1989 (Myanmar Development Resource Institute and Michigan State University, 2013). The slower growth in rice production compared to that of the area under rice cultivation can partly be explained by a decrease in the application rate of fertilizer. The average amount of fertilizer (including nitrogen, phosphates and potassium (NPK)) used was 5 kg per hectare in 2009 at the national level (Department of Agricultural Planning, 2013b). The average use of fertilizer was 75 kg per hectare in 1985-1986, but the amount has ranged between 30 to 60 kg since the 1990s (Okamoto, 2008). The average use of fertilizer was lower in Myanmar than it was in other Asian countries (FAO, 2009).

2.2.2 Agricultural policies and reforms

Agriculture policy (1962-1988)

Prior to 1963, the government practised the state procurement system, and allowed farmers to make their own decisions regarding crop choice, cropping patterns and sales of their produce (Thein, 2004). However, the socialist government (1974-1988) had a monopoly over agricultural trade: the private sector was not allowed to trade agricultural products either domestically or internationally. The objective of this policy was to ensure the sufficient supply of food to meet food security at the low prices of agricultural products. To fulfil this objective, the government introduced state control and intervention for all food production activities. The government launched sales of a fixed quota of food grains and a compulsory paddy procurement. Under this policy, farmers had to sell a fixed quota of food grains (including rice) to the government, and were prohibited from selling their produce directly to customers. The delivery quota for each farmer was 30-40 baskets of paddy per acre (1.5-2.1

tons per hectare) at low official prices (Okamoto, 2005). The government also monopolized rice exports, the country's main source of foreign currency.

During this period, the Revolutionary Council Government of Myanmar also introduced a 'Land Nationalization' policy (Thein, 2004). Under this policy, the government nationalised all private farm holdings, and the land holding rights of farmers were reduced to land tilling rights that needed annual registration and renewal. Farmers were strictly prohibited from transferring their land tilling rights, including through the division, sale, lease or mortgage of their land. The maximum amount of paddy land per farm household was set at 50 acres. Under this framework, large amounts of agricultural land that exceeded the maximum limit of 50 acres were taken and redistributed to tenant farm households followed by smaller land holders and landless labours (Okamoto, 2008). A 'Pillar Crops' policy introduced a system that classified cultivated land as 'planned crops areas' (in which farmers had to grow planned crops for supporting the compulsory delivery system) and 'non-planned crops areas'. Land tilling rights were tightly connected with the both compulsory delivery system and the planned cropping system. Farmers that did not fulfil the requirements of either system, could lose their land tilling rights (Soe et al., 2004).

As a result of these systems, farmers lacked motivation and incentives to invest in both land improvement and productivity. Although the government provided fertilizer subsidies, there was no significant improvement in production from 1962 to 1973. The first reason for this was that the government could provide only 20 per cent of the required amount of fertilizer, leading farmers to purchase the remaining amount of fertilizer at prevailing market prices. This pushed up production costs and decreased farmers' incomes. Another reason for no improvement in rice production was that there was no motivation for farmers to increase their production levels because the quota amount that they had to sell to the government would also rise (Soe et al., 2004). Consequently, there was a gradual decrease in productivity that resulted in the slow development of the rural economy.

In September 1987, the government implemented the first agricultural reform and introduced advanced technology to develop the agriculture sector. The government also lowered the delivery quota for paddy to 10-12 baskets per acre (0.5-0.6 tons per hectare) compared to that of 30-40 baskets per acre under the socialist period (Fujita et al., 2009). In the 1990s, the delivery quota of paddy usually accounted for 10 to 12 per cent of the produce. In September

1988, the military government, the State Law and Order Restoration Council (SLORC), lifted restrictions on the private export of some agricultural crops such as black gram, green gram, maize and pigeon pea. However, rice remained under state control through the Association of Myanmar Agricultural Produce Trading (MAPT). In addition, subsidies on fertilizers, seeds and pesticides were gradually transferred from the Myanmar Agriculture Service (MAS) to the private sector. On the positive side, farmers could freely decide the types of crops to plant and sell their produce in any market without restriction.

Agriculture policy (1988 to present)

In 1992-1993, the government initiated the summer paddy production program (SPP) with the expansion of land and irrigation facilities to further promote the production of rice. The area under rice cultivation expanded from 12.114 million acres in 1985-86 to 15.528 million acres in 1999-2000. To support the SPP, the Irrigation Department constructed 108 irrigation projects including dam and reservoir projects between 1988 and 1999 (Thein, 2004). The government also provided subsidised inputs, especially diesel fuel and fertilizers, and agricultural extension services in the planned areas.

Moreover, other crops, including pulses, sugar-cane and cotton, were also identified as 'pillar crops' to develop the agriculture sector. Rice and the other main pillar crops accounted for 64 per cent of total sown acreage in 1999-2000 (Thein, 2004). Rice production significantly increased from 14.09 million tons in 1985-1986 to 19.81 million tons in 1999-2000. Similarly, the production of pulses dramatically increased from 0.61 million tons in 1985-1986 to 1.88 million tons in 1999-2000 (Thein, 2004).

In 2003, the government launched a new policy, the so-called 'second agricultural reform', which abolished the restrictions of the old procurement system and liberalised both domestic and export markets for agricultural produce. Farmers could freely cultivate crops and sell their produce in markets. As a result of the 1987 and 2003 reforms, and the SPP, rice production increased remarkably from 13.83 million tons in 1989-1990 to 32.58 million tons in 2010-2011 (Department of Agricultural Planning, 2012). Similarly, there was a significant increase in pulse and bean production, accounting for 4.27 million tons in 2006-2007 compared to 0.37 million tons in 1988-1989 (Zaw et al., 2011).

The government has also implemented other programs to boost rice production including the provision of extension services and agricultural loans, and the expansion of irrigation. The Department of Agriculture (DOA) has provided extension services since 1927 including educational activities, distribution of seeds, fertilizers and pesticides. The Central Agriculture Research Institute (CARI) and Myanmar Agriculture Services (MAS) have taken responsibility for research and extension activities. The Irrigation Department, Ministry of Agriculture and Irrigation (MOAI) constructs dams and reservoirs throughout the country. In 2014, the Irrigation Department completed the projects of 240 dams, 327 river pumping stations and 12,258 groundwater projects (Department of Agricultural Planning, 2014b).

Since 1953, the Myanmar Agricultural Development Bank (MADB) under the Ministry of Agriculture and Irrigation (MOAI) has been the main financial institution providing loans to farmers at subsidised interest rates. The MADB provides banking services across the country to develop the agriculture sector, including livestock and fishery, and rural socio-economic enterprise across the country. The MADB mainly provides seasonal loans for crop production, term loans and loans for area development. In 2012-2013, the bank lent nearly 570 billion Kyat to improve rice production (Win, 2013). Farmers can borrow up to 100,000 Kyat (100 USD) per acre, up to a maximum of 10 acres from the MADB at an interest rate of 8.5 per cent per annum (around 0.71 per cent per month). However, the scheme excludes landless farmers who do not have the requisite land use certificates needed to be eligible for the MADB agricultural loans. Between 25 to 50 per cent of rural farmers are unable to access credit due to the lack of land use right certificates (Haggblade et al., 2014).

Further, despite the subsidy, the MADB's loans are insufficient to cover rice production costs, which are estimated to be around 200,000 Kyat (200 USD) per acre (De Luna-Martinez and Anantavrasilpa, 2014). In this case, farmers make up the difference from other sources, such as friends, relatives, landlords, neighbours, money lenders, pawnshops, traders and suppliers of agricultural inputs and loan sharks. Among the informal sources, borrowing from family and friends are the most common sources of loans. According to the Household Living Condition Survey reported by Dapice et al. (2011), the percentage of farm households in debt was 30 per cent in 2010. LIFT (2012) found that 42 per cent of their sample households borrowed money from family and friends, and 31 per cent took loans from money lenders. However, the interest rate charged in informal markets is relatively high at 5 per cent to 20 per cent per month, which increases the cost of loans on farmers (LIFT, 2012). Their findings showed the highest interest rate in one village of Ayeyarwaddy that charged by money lenders was 8 per cent per month. Consequently, many farmers cannot afford agricultural inputs such as seeds, chemical fertilizer, and labour, which contributes to low agriculture sector productivity (FAO, 2016). Food Security Working Group (2015) also showed that a lack of access to credit is the major constraint to buy the necessary inputs (fertilizers and pesticides) at high prices, and hire labours at high wages due to shortage of household labours in their study in Ayeyarwaddy Delta, Dry zone and Hilly areas. In this study, 32 per cent of households also borrowed money from relatives at an interest rate of around 5 per cent, 6 per cent and 8 per cent per month in Sagaing, Bago and Ayeyarwaddy. Limited credit, therefore, is one of the challenges facing Myanmar's rice production.

2.3 Literature review

Rice plays an important role in the food systems and economies of many developing countries. Over 50 per cent of the world's population depends on rice for its staple food and their livelihood (Department of Agricultural Planning, 2013b). Although rice production has been increasing since the 1960s, the growth rates of rice production have been slower than the world's population growth rates since the 1990s (Duwayri et al., 2000). To ensure the food security of their population, governments in many countries are trying to raise rice production to help ensure national food security. However, the efficiency of rice production depends on many factors, including the education level of farmers, soil quality, irrigation systems, farm sizes, agricultural extension services and access to credit (Than, 2011). On the other hand, the technical efficiency of a farm, especially small farm, is affected by other various factors including 'demographic characteristics, farm's characteristics, socioeconomics, environmental factors and non-physical factors' (Rahman et al., 2009, p.90).

In an attempt to examine which factors determine the efficiency in rice production, a number of studies have used a stochastic frontier production combined with the technical inefficiency model to investigate the determinants of efficiency in rice production. In this approach, efficient farms can produce the maximum level of outputs with given technology and inputs at a given period of time. Those farms are able to operate on the production frontier function compared to those who inefficiently operate below the production frontier function. By applying this approach, a number of studies have analysed several factors affecting the efficiency of rice production in different countries. Some studies have shown the importance of the educational level of household head, access to agricultural extension services, farming experience and land fragmentation in rice production. At the same time, others have paid attention to access to credit, the availability of loans, and infrastructure including the development of roads and irrigation systems, and their effects on productivity. For example, Kompas et al. (2012) showed that farms with more educated farmers, effective extension services and better irrigation systems could improve Vietnamese rice production. Idiong (2007) and Rahman et al. (2012) found that the educational level of household head had a positive impact on rice production efficiency in Cross River State in Nigeria and Bangladesh respectively.

Although work has been focused on these factors in many studies, there has been limited research on rice productivity and efficiency in Myanmar. Aung (2011), and Myint and Kyi (2005) found a positive relationship between educational level of household head and a farm's efficiency in the selected areas in Myanmar. They also demonstrated the influence of extension services on Myanmar's rice production including the provision of educational activities; the collection of information on problems such as pests, diseases, soils management, and the use of fertilizers; and finding the solutions to those problems. These findings were consistent with those of Kompas et al. (2012) and Thangata and Mequaninte (2011) who found that extension services significantly improved farm household efficiency in producing rice in Vietnam and Ethiopia. In contrast, Kyi and von Oppen (1999) argued that farming experience and the educational level of household head had no impact on a farm's rice production efficiency in Myanmar, especially in the Delta Region.

Increased amounts of credit enables farmers to purchase more production inputs including seeds and chemical fertilizers. In general, the credit market consists of formal markets and informal markets. Informal credit markets play an essential role in reducing financial problems for individual, small business and farmers, especially in many developing countries, although the interest rates of loans in informal markets are higher than that of in formal markets (Tang, 1995). Akinbode (2013) demonstrated a positive effect of the availability of credit from formal markets, for example, microfinance banks and cooperative societies, on rice production in Nigeria. Adebayo and Adeola (2008) also found that the availability of credit could raise rural living standards in Nigeria by increasing productivity. Duong and Izumida (2002) had similar findings on the impact of credit markets in Vietnam. However, there has not been any empirical research on the availability of credit for rice production in Myanmar. This paper helps to fill the deficiency by explaining the relationship between credit availability and rice productivity in the selected regions in Myanmar.

Similarly, there has been no literature that examines the influence of infrastructure on rice production, and the importance of its role in the development of the rural economy in Myanmar. In general, good infrastructure contributes to economic growth, poverty alleviation and environmental sustainability (Staff, 1994). Better transportation plays an important role in rural development, as productivity and employment rely heavily on the provision of transport infrastructure (Staff, 1994).

DeSilva (2011), Omondi and Shikuku (2013) and Sibiko et al. (2013) demonstrated that distance to market had been an important determinant of productivity efficiency in the Philippines, Kenya and Uganda respectively. They suggested that improvement in rural infrastructure could improve the efficiency of rice productivity. However, Schneider and Gugerty (2011), and Velarde et al. (2013) argued that there was no significant effect of distance to market on agricultural productivity in Bangladesh and the Philippines.

2.4 Data source and variables

In this study, primary field survey data collected in the most rice growing regions, specifically, Ayeyarwaddy, Bago and Sagaing in 2014 is used for the estimation of stochastic frontier production. The number of farm households in this study totalled 634 farms across 30 villages in 6 townships. The sampling framework is described in Appendix A.

In order to capture the farm-specific factors that have an impact on rice production efficiency, variables such as total value of rice, land, capital, labour, total costs of inputs including fertilizers, pesticides, and total cost of a variety of seeds are analysed in this essay. In general, a higher price of seed may be expected for good quality seed that produces high yield. However, the varieties of seed and suitable areas of plantation should also be taken into account in the efficiency of rice production. The varieties of seed can be mainly classified as hybrid variety, high yielding variety (HYV), high quality variety and local variety (Agricultural Extension Division, 2013). High quality of paddy, namely, Paw San, which was awarded the World's Best Rice Premium at the World Rice Conference in 2011 (Myint and Napasintuwong, 2016), and other high quality rice paddy are planted only once in a year, especially in the Ayeyarwaddy and Sagaing regions. Additionally, the price of high-quality seed is nearly double the price of high yield varieties (HYVs) (Myanmar Development Resource Institute and Michigan State University, 2013).

However, the average yield per acre of high quality seed is relatively low in comparison with the average yield per acre of HYV and hybrid varieties, accounting for 2.7 MT per hectare, 3.7 MT per hectare and 4.5 MT per hectare respectively (Department of Agricultural Planning, 2013b). Approximately 50 per cent of farm households in the selected areas use the high-quality seed. To take into account the heterogeneity in rice varieties, the value of rice is used in this analysis. All inputs in the production function are also used in terms of their value. The cultivated land size is measured in acre.

The factors that determine rice production efficiency are investigated in terms of average years in school of household members who are engaged in agricultural activities, farm size and number of plots, irrigation systems and agricultural extension services in this study. The availability of credit includes credit from formal and informal credit institutions. In this study, formal credit institutions consist of the MADB and NGOs, while informal credit sources include relatives, friends and pawnshops. Finally, the distance from village to market nearby a township is also analysed for its impact on rice production.

2.5 Methodology

2.5.1 Stochastic Frontier Production Model and Technical Inefficiency Model

In an attempt to analyse the productivity and efficiency gains in rice production in Myanmar, the stochastic frontier model is applied to determine the factors affecting production efficiency. Aigner et al. (1977) and Meeusen and Van den Broeck (1977) first developed the stochastic production frontier approach to apply cross-sectional data. In this model, the deviation of actual observations from potential output is divided into two components. The first component investigates the set of determinants that prevented economic units from reaching their maximum potential output given the data set of inputs, and the second component represents the stochastic error. This model was further extended to apply to panel data, following Battese and Coelli (1995). The model for the cross-sectional data for the i^{th} firm can be expressed as

$$Y_i = f(X_i, \beta)e^{(\nu_i - \mu_i)} \tag{2.1}$$

where Y_i is total value of rice of the i^{th} firm, X_i is a (1xK) vector of explanatory variables determining the level of output, β is a (Kx1) vector of parameters to be estimated, and ν_i is the random error following the normal distribution $N(0,\sigma^2)$. The error term μ_i is a one-sided non-negative disturbance term that captures the technical inefficiency in production, identified by

$$\mu_i = Z_i\delta + \omega_i \tag{2.2}$$

where z_i is a (1 x M) vector of the inefficiency explanatory variable, δ is a (M x 1) vector of coefficients to be estimated, and ω_i is a random variable to ensure non-negative truncations (at zero) of the distribution $N(Z_i,\sigma^2_\mu)$.

Battese and Corra (1977), and Battese and Coelli (1993) defined the variance terms as $\sigma^2 = {\sigma^2}_\mu + {\sigma^2}_\nu$ and $\gamma = \frac{{\sigma^2}_\mu}{({\sigma^2}_\mu + {\sigma^2}_\nu)}$.

The technical efficiency for the i^{th} firm is defined as

$$TE_i = \frac{E(Y_i/\mu_i, X_i)}{E(Y_i/\mu_i = 0, X_i)} = e^{-\mu_i} = e^{(-z_i\delta - \omega_i)} \tag{2.3}$$

Equations (2.1) and (2.2) are estimated by using Frontier 4.1 with details of the estimations described by Coelli (1996). The value of technical efficiency (TE_i) must be between zero and one. If $\gamma = 0$ where there are no deviations from the potential frontier due to inefficiency and $\gamma = 1$ then there are no deviations from the stochastic disturbance. Therefore, overall mean technical efficiency becomes

$$TE = \{\frac{1 - \phi[\sigma_\mu - (\mu/\sigma_\mu)]}{1 - \phi(\mu/\sigma_\mu)}\}e^{\mu + (\frac{1}{2})\sigma^2_\mu} \tag{2.4}$$

where $\phi(.)$ represents the density function of a standard normal variable.

In order to test the influence of inefficiency effects, the generalized likelihood ratio test is used to determine the specification of equations (2.1) and (2.2) that are given by the test statistic

$$LR = -2\{ln[L(H_0)] - ln[L(H_1)]\} \tag{2.5}$$

where $L(H_0)$ and $L(H_1)$ are the values of likelihood function under the null hypothesis (H_0) and alternative hypothesis (H_1). The critical values for test statistics are drawn from a mixed χ^2 distribution as reported by Kodde and Palm (1986). If the scalar parameter γ and all the δ parameters are equal to zero (γ=0 and δ_i=0 for all i) then this suggests that there is no impact on the inefficiency effects. In this regard, the ordinary least-squares (OLS) regression can be used efficiently to estimate the model. On the other hand, if all the δ parameters are equal to zero (δ_i=0 for all i>0), then the ordinary least-squares (OLS) regression is not appropriate and a stochastic frontier can be applied in this study.

Mutter et al. (2013) argued that there might be the endogenous explanatory variables in the frontier or inefficiency functions of the stochastic frontier model. The endogeneity would occur if the determinants of frontier or inefficiency are correlated to error term. In this case, stochastic frontier model estimations do not handle the endogeneity in the model. In order to control the endogeneity in the frontier, or inefficiency or both functions, they provided a maximum-likelihood-based approach. Furthermore, Karakaplan et al. (2017) has recently developed the 'sfkk' command for fitting endogeneous stochastic frontier models.

2.5.2 Econometric model specification

The variables considered in the production model are total cultivated land areas, total value of capital owned and rented, labour cost, seed cost, and expenditure on fertilizers and pesticides. The owned capital includes both draft animals and tractors that households use in their rice cultivation. The local price of hiring capital in each village is used for the calculation of owned capital. The cost of owed capital is calculated multiplying a number of working days by the local daily rate of hiring draft animals and/or tractors. The rented capital is the total cost of hiring oxen, buffaloes, tractors and harvesters, as well as the cost of hiring other equipment, such as water pumps and thresher machines for land preparation and harvesting, and measured in thousand Kyat.

The variable for labour comes from both family labours and hired labours. The total labour cost is the sum of labour cost ('000 Kyat) for family members and that for hired labours from other households for land preparation, sowing, planting and harvesting. The local daily wage rate for casual workers in each village is used to compute the family labour cost. The number of working days for family labour is multiplied by local daily wage rate of casual worker in each village. Expenditure on agricultural inputs ('000 Kyat) is the sum of the costs of fertilizers and pesticides. The variable for seed is the total cost of different variety of seeds used by a household, measured in thousand Kyat. The dummy variable for region is identified as 1 if farm households are located in the Delta Region; otherwise it is 0.

Therefore, the stochastic production function is

$$\begin{aligned} lnY_i = \beta_0 + \beta_1 lnLAND_i + \beta_2 lnK_i + \beta_3 lnLAB_i + \beta_4 lnINPUTS_i \\ + \beta_5 lnSEED_i + \beta_6 REGION_i + \nu_i - \mu_i \end{aligned} \tag{2.6}$$

where Y is the total rice value measured in thousand Kyat, LAND is the total cultivated area measured in acres for the annual crop production, K is the total cost of both owned and rented oxen, buffaloes, tractors and harvesters, LAB is the sum of labour costs for both family members and hired labours, INPUTS is the total expenditure for all material inputs, SEED is the total value of seed, and REGION is the dummy variable for farm households in the Delta Region.

The technical inefficiency model for the stochastic frontier production function is

$$\begin{aligned} \mu_i = \delta_0 + \delta_1 YEAR_i + \delta_2 SIZE_i + \delta_3 PLOTS_i + \delta_4 CREDIT_i + \\ \delta_5 IRRI_i + \delta_6 AES_i + \delta_7 ln(DIST_i) + \omega i \end{aligned} \tag{2.7}$$

Other variables, such as average years in school of household farm workers, the presence of irrigation systems, farm size and number of plots, agricultural extension services, the availability of credit and distance to market are included in the inefficiency model. YEAR is an average schooling years of household members who are engaged in farming activities, Land (LAND) is the total cultivated land area (both owned and rented), land size (SIZE) is household's total landholding area (both owned and rented), and PLOTS describes the number of plots for each farm.

Irrigation (IRRI) is the availability of water from natural and irrigated water including creek, rivers, dams and reservoirs, and private channels defined as dummy variable (1=good/very good 0=otherwise). Agricultural extension services (AES) is defined as a binary variable if a farm household receives services from different institutions for farming activities (=1) or otherwise (=0). CREDIT is the total credit ('000 Kyat) that farms can borrow from formal and informal financial institutions. Access to market (DIST) is defined as the distance from each village to markets nearby a township measured in kilometres.

Additionally, the variable of credit in the inefficiency model is concerned as endogenous variable. The source of endogeneity for credit comes from the selection bias and the government's targeting scheme. Although the government provides more credit to small farmers, those farmers may not be as efficient and may use credit for consumption instead of enhancing production efficiency. To handle the endogeneity, the instrumental variable (IV) is needed to use in the 'sfkk' command that developed by Karakaplan et al. (2017). In this study, the IV takes the value of 1 if a farm household has a maximum of 10 acres of land and IV is 0 if it is otherwise.

2.6 Results from the data

2.6.1 An analysis of the main specification

Table 2.1 presents the summary statistics for paddy production in the farm household survey data. Due to the double-rice cropping pattern, especially in the Delta Region, an average cultivated land size for each household is 13.71 acres. The average value of rice is seen as around 3,300 ('000 Kyat) for household. Total cost for working capital is nearly 415,000 Kyat on average, while total labour cost is around 900,000 Kyat. The expenditure on inputs including chemical fertilizer and pesticide accounts for 256,000 Kyat. The average cost of seed for each farm household is 205,500 Kyat on average. About 67 percent of total 634 farm households is located in the Delta Region, and 33 per cent of households is located in the Central Dry Zone.

Table 2.1 Summary statistics for paddy production in the farm household survey data

Variable	Units	Mean	Std.Dev	Min	Max
Paddy Value(Y)	000 Kyat	3299.41	3638.79	250	24750
Land (LAND)	acre	13.71	12.96	1	84
Capital (K)	000 Kyat	414.64	449.89	0	3840
Labour (L)	000 Kyat	894.86	926.44	16	6492.50
Inputs (INPUTS)	000 Kyat	256.71	427.83	0	3680
Seed (SEED)	00 Kyat	2055.52	2138.03	17.50	22400
Delta Region (REGION)	yes=1	0.67	0.47	0	1
Schooling years (YEAR)	years	6.51	2.42	0	15
Landholding size (Size)	acre	11.64	11.31	1.37	70
Number of plots (PLOTS)	number	1.72	1.17	1	10
Irrigation (good/very good) (IRRI)	yes=1	0.82	0.38	0	1
Agricultural extension services (AES)	yes=1	0.58	0.49	0	1
Amount of credit (CREDIT)	000 Kyat	1363.35	1287.71	0	9000
Distance to market (DIST)	km	17.02	19.65	1.61	96.56
Number of farm households (N)	634				

The average years of studying in school is approximately seven years showing that household members who work in farming activities have attained at most secondary school education. An average landholding size for each household in the selected regions is 11.64 acres with holdings of 2 plots on average. Around 82 per cent of households are found to be satisfied with the availability of irrigated water. More than half of farm households receive agricultural extension services. The availability of credit received by each farm household from both the formal and informal sectors accounts for 1,363 ('000 Kyat). The average distance from a village to a market nearby a township is nearly 17 km.

Table 2.2 Generalized Log-Likelihood Ratio Test for the Stochastic Production Frontier and Technical Inefficiency Models

Null Hypothesis	Likelihood Ratio	$\chi^2{}_{0.99}$ Statistic	Decision
1. $\gamma = \delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = 0$	221.50	20.97	RejectH_0
2. $\gamma = 0$	68.84	5.41	RejectH_0
3. $\delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = 0$	97.61	17.76	RejectH_0
4. $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = 0$	88.99	22.53	RejectH_0

Table 2.2 reports the likelihood ratio (LR) tests. The likelihood ratio (LR) test in this study is analysed for the specification of the technical inefficiency. This likelihood ratio (LR) test has the distribution of mixed chi-square (χ^2) with restrictions. The critical values of the distribution are obtained from Kodde and Palm (1986). In Table 2.2, the value of the log likelihood test is calculated from the values of likelihood function under the null hypothesis $L(H_0)$ and the alternative hypothesis $L(H_1)$ in Equation (2.5).

Firstly, the null hypothesis $L(H_0)$ implies that there is no effect of technical inefficiency in rice production if the values of γ and δ_i are equal to zero (γ=0 and δ_i=0 for all i). Secondly, the null hypothesis $L(H_0)$ for the value of γ is equal to zero (γ=0) implying that there is no stochastic inefficiency effect. Thirdly, the null hypothesis for δ_i=0 (for all i) indicates that all explanatory variables in technical inefficiency model may not significantly contribute to any explanation for the effects of inefficiency. Finally, if the value of δ_i is equal to 0 (δ_i=0 for all i>0), the null hypothesis $L(H_0)$ will suggest that there has been no influence of farm-specific factors on technical inefficiency in Equation (2.4).

If the first null hypothesis is accepted, all variables in the technical inefficiency model should be included in Equation (2.3). However, the null hypothesis ($\gamma = \delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = 0$) is rejected at the 1 per cent significance level, as the value of likelihood is greater than the value of the chi-square (χ^2). The result, therefore, strongly suggests that there has been no absence of inefficiency in this model. The second null hypothesis ($\gamma = 0$) is also rejected. This result supports the hypothesis that technical inefficiency significantly affects rice production.

As shown in Table 2.2, all variables in the technical inefficiency model can explain the inefficiency effects due to the rejection of the third null hypothesis. Finally, the null hypothesis for all δ_i=0 (i>0) is also rejected. This finding clearly states that there has been a significant influence of farm-specific factors on rice production, specifically in the selected regions of Myanmar. Therefore, all results indicate that stochastic effects and technical inefficiency are important factors in explaining the production efficiency function and, therefore, that conventional OLS estimates are not appropriate in this model.

The results for the stochastic frontier production model and the technical inefficiency model are shown in Table 2.3 by controlling endogeneous variable of credit with the IV variable. The coefficient for the cultivated land in the stochastic production frontier model is 0.64. The coefficient of land is relatively high compared to the coefficients of capital and labour. This is because most people living in Myanmar's rural areas rely heavily on agricultural land for their livelihood, suggesting that land is a key factor in increasing rice production.

The coefficient of capital is relatively small and statistically insignificant. One of the important factors for expenditure on inputs is the depreciation of asset owned by households that should be taken into account in the analysis. Unfortunately, this variable could not be included in this study due to the lack of precise information for rural Myanmar. However, it may not cause a significant concern for the context of Myanmar when the data was collected for two reasons. First, the expenditure on capital is relatively small compared with the total cost. Second, this study uses the cross-sectional data, therefore, it would slightly underestimate the capital cost for all households in the sample. In this case, the coefficient estimate of capital cost might be slightly over-estimated.

The coefficient of labour is 0.14 in the production function. The positive and significant coefficient of labour suggests that there is a positive relationship between labour and rice production. A 1 per cent increase in spending on labour can significantly increase rice value by 0.14 per cent. Taking the results of capital and labour together, it is clearly seen that rice production in Myanmar is still labour intensive.

A number of empirical studies, for example, those conducted by Kompas et al. (2012) and Rahman et al. (2012), demonstrated a positive relationship between rice production and expenditure on fertilizer in Vietnam and Bangladesh respectively. Consistent with their findings, the result of inputs (fertilizers and pesticides) on rice production confirms a positive and significant effect on rice production. The FAO (2009) has reported that the use of fertilizer in Myanmar for rice production is relatively low at an average of 12 kg per hectare (5 kg per acre) at the national level. However, recent studies by Lwin et al. (2014), and Food Security Working Group (2015) have found in their studies that the average use of fertilizer is 220 kg per hectare on average, approximately 125 kg per hectare (52 kg per acre) for monsoon paddy and 290 kg per hectare (119 kg per acre) for summer paddy.

The average use of fertilizer in this study is 140 kg per hectare (57 kg per acre) for monsoon paddy and 178 kg per hectare (72 kg per acre) for summer paddy. Although the average use of fertilizer in these three regions is approximately 141 kg per hectare (57 kg per acre), the amount of fertilizer varies among the regions. In particular, the application rate of fertilizer is 173, 56 and 197 kg per hectare (69, 23 and 80 kg per acre) in Ayeyarwaddy, Bago and Sagaing respectively. The amount of fertilizer used in Sagaing is relatively larger than that of other regions. Based on this application rate, expenditure on fertilizer is approximately 20,000 Kyat (USD 20) per acre. In this case, most farmers spend 20 per cent of their credit from the MADB for the purchase of fertilizer, as the credit provided by the MADB is 100,000 Kyat (USD 100) per acre. The result of fertilizer and pesticide on rice production suggests the effective application of fertilizer in Myanmar's selected regions.

The coefficient of expenditure on seed shows a positive effect on production. Farm households usually use seed around 42 kg per acre although the use of seed varies across regions. Among 634 farm households, 60 per cent of households used less than 42 kg per acre. The coefficient of seed indicates that those households who use lower than 42 kg can raise their rice value by approximately 0.2 per cent if they increase the expenditure on seed by 1 per cent.

The dummy variable for region shows the benefits of growing rice in the Dry Zone compared to the Delta Region. As explained in Section 2.4, Ayeyarwaddy in the Delta Region and Sagaing in the Dry Zone are famous for Paw San rice. However, farm households in Sagaing are found to receive higher rice value than that of farm households in the Delta Region.

Table 2.3 Endogeneous Stochastic Production Frontier and Technical Inefficiency Model I

Variables	coefficient	standard error	t-ratio
Stochastic Production Frontier			
Constant	4.254***	0.218	19.54
Land (LAND)	0.642***	0.050	12.84
Capital (K)	-0.001	0.003	-0.38
Labour (LAB)	0.139***	0.031	4.43
Inputs (INPUTS)	0.006**	0.003	2.35
Seed (SEED)	0.229***	0.031	7.50
Region (REGION)	-0.220***	0.044	-4.99
Technical Inefficiency Model			
Constant	0.283	0.387	0.73
School year (YEAR)	-0.044*	0.025	-1.73
Land size (SIZE)	0.030***	0.010	-3.03
Plots (PLOTS)	0.022	0.061	0.36
Irrigation (IRRI)	-1.146***	0.179	-6.40
Agricultural Extension Services (AES)	-0.325**	0.140	-2.32
Credit (CREDIT)	0.005	0.025	0.19
Distance to market (DIST)	0.119	0.074	1.61
Log–Likelihood	-1933.76		
Mean technical efficiency (%)	0.67		
Number of observations	634		

Note: *, ** and *** correspond to statistical significance at 10%, 5% and 1% levels respectively.

Given the importance of better education in raising production efficiency, the coefficient of education should be associated with production inefficiency. In the previous studies, Sriboonchitta and Wiboonpongse (2000) found a negative relationship between education and efficiency in rice production in the case of Thailand. Contrary to him, Aung (2012) and Kompas et al. (2012) have explained that better-educated farmers have a positive impact on production efficiency. The result of this study is consistent with the findings of these two authors (Aung, 2012; Kompas et al., 2012); this study also finds the strong indication that the average years in school of household farm workers has a positive effect on productivity. The coefficient of schooling years indicates that household workers who are engaged in farming activities with better education increase production efficiency.

The negative coefficient of farm size shows that larger land size can significantly decrease the inefficiency of farm's productivity. This result is consistent with Kompas et al. (2012) who found a negative relationship between landholding size and production inefficiency. The result confirms that farm households with large farm size are likely to increase the efficiency of rice production.

Wan and Cheng (2001) argue that farms with a large number of plots have a negative and significant effect on productivity. Unexpectedly, the coefficient of plots show a positive relationship with production inefficiency, but the result is not statistically significant. The average number of plots for each land size is approximately 2 plots, while a maximum number of plots for holding land is 10 plots. In this study, the number of plots has little influence on rice value.

Consistent with the previous study (Kompas et al., 2012), the coefficient of irrigation illustrates the positive impact of irrigation systems on efficiency in rice production. This means that better irrigation system plays an important role in reducing technical inefficiency. The coefficient value of AES is relatively large and significant, showing that provision of effective services helps improve rice productivity. This finding agrees with that of Myint and Kyi (2005), who found a positive effect of AES on rice production. However, only 35 per cent of total farm households were found to receive the extension services from Myanmar Agriculture Services (MAS) in this survey. This result clearly suggests that the MAS should provide training and education through Farmers Field Schools (FFS). The MAS should also prioritise the distribution of quality seed, fertilizer and farm equipment, and training in production technology (Cho, 2013).

Generally, farms will grow rice efficiently if they receive more credit (Kompas et al., 2012). In this regard, an analysis of credit shows little impact on rice production as the coefficient of credit is not significant. One of the reasons for that is limitation on the availability of loans provided by the Myanmar Agricultural Development Bank (MADB). As previously described, farmers can receive loans from the MADB up to a maximum of 10 acres (nearly 4.04 hectare). This implies that farm households holding more than 10 acres have insufficient credit as they cannot apply loans from the bank on the basis of their land size. This credit system, therefore, fundamentally benefits those farmers with a relatively smaller farm size rather than those with larger farm size.

In general, there is a negative impact of longer distance to market on rice production. DeSilva (2011) found a negative relationship between distance to market and production efficiency in the Philippines. Good road access and closer proximity to the market reduces the farm household's travelling time and cost of transportation, and allows them to buy inputs easily and sell their produce at better prices (Sibiko et al., 2013). The coefficient of distance is positively correlated with rice production, but, the result is not significant. There is little impact of the distance from a village to the nearest market on rice value in the selected region.

Table 2.4 shows the summary of the technical efficiency score of the selected farm households. The estimated mean efficiency score lies between 0.05 and 0.95. The results shows that approximately 30 per cent of farm households operates below the mean efficiency score, while nearly 55 per cent of households operates above the mean efficiency of 0.67. Overall, the mean technical efficiency level of 0.67 suggests that Myanmar can increase its productivity by 33 per cent, particularly in the selected regions.

Table 2.4 Technical efficiency score of the selected farm households

Efficiency score	Frequency	Percentage (%)
0.01-0.20	17	2.68
0.21-0.30	22	3.47
0.31-0.40	31	4.89
0.41-0.50	46	7.26
0.51-0.60	75	11.83
0.61-0.70	95	14.98
0.71-0.80	161	25.39
0.81-0.90	156	24.61
0.91-1.00	31	4.89
Total	634	100
Maximum TE	0.95	
Minimum TE	0.05	
Mean TE	0.67	

2.6.2 Econometric model specification with Township Fixed-Effects

As is shown in Table (2.3), the coefficient of agricultural extension (AES) is statistically significant at 5 percent levels. However, AES variable might be endogenously determined if extension services are devoted to the location of villages where they are much closer to the providers, and responsiveness to extension services. The extension services provider might pay more attention to provide services to areas where rice production is high. In this connection, the service provision is positively correlated with the error term in the model explaining rice production, and causing endogeneity problems. The greater the distance to a village, the costlier it is for the service providers to get that village. Farmers from villages with better connection to the Agricultural Extension Department (AED) are likely to have access to extension services and higher production efficiency. To address this problem, a dummy variable for each village, so-called fixed-effects or the Least Square Dummy Variable model should be applied.

However, this study uses the township fixed-effects (TFE) instead of village fixed-effects (VFE), as it is not possible to control the endogeneity problems for VFE. The effects of village-level variables, such as the distance and the provision of AES cannot be estimated because the fixed-effect estimator uses within-village variation, not between-village variation for its estimation. Since there is no within-village variation for village-level variables, no estimates can be obtained (Mundlak, 1978). The township fixed-effects, therefore, is included in Equation (2.9). This survey was conducted in 4 townships in the Delta Region and 2 townships in the Dry Zone. The variable for township fixed effect is defined as dummy variable for each of the townships. The endogeneous stochastic frontier production frontier model, therefore, is applied to handle the endogeneity issue.

All variables used in main specification I are included in this technical inefficiency model. Therefore, the stochastic production function for specification II is

$$\begin{aligned} lnY_i = \beta_0 + \beta_1 lnLAND_i + \beta_2 lnK_i + \beta_3 lnLAB_i + \\ \beta_4 lnINPUTS_i + \beta_5 lnSEED_i + \nu_i - \mu_i \end{aligned} \tag{2.8}$$

The technical inefficiency model for the specification II is

$$\begin{aligned}\mu_i = \delta_0 + \delta_i YEAR_i + \delta_2 SIZE_i + \delta_3 PLOTS_i + \delta_4 IRRI_i + \delta_5 AES_i \\ + \delta_6 ln(CREDIT_i) + \delta_7 ln(DIST_i) + \delta_8 TFE_i + \omega i\end{aligned} \tag{2.9}$$

The results for the stochastic frontier production model and the technical inefficiency model for specification II with controlling the endogeneity and township fixed-effects are shown in Table 2.5.

The result of the stochastic frontier production model for specification II is much similar to the main specification I. Although the coefficient of cultivated land is positively and statistically significant at 1 percent level, the magnitude is quite large. The coefficient of expenditure on capital is not statistically significant as main specification model I. The expenditures on labour and seed have a positive and significant impact on rice production. However, the coefficient of input is not significant in this specification.

The coefficient of average schooling years of family members who are engaged in rice production have negative signs as expected, but, the result is not statistically significant. The coefficient of distance in this specification demonstrates its negative impact on production efficiency. The result of credit is found to be robust as its coefficient is insignificant. This result strongly confirms that there is little impact of credit on rice production. Similarly, the coefficient of AES has a negative effect on technical inefficiency of rice production with or without control for fixed-effects. The results shows that the coefficients are robust to differences between villages within each township.

Table 2.5 Stochastic Production Frontier and Technical Inefficiency Model II

Variables	coefficient	standard error	t-ratio
Stochastic Production Frontier			
Constant	4.011***	0.223	17.99
Land (LAND)	0.721***	0.049	14.71
Capital (K)	-0.003	0.003	1.00
Labour (LAB)	0.122***	0.033	3.70
Inputs (INPUTS)	0.004	0.003	1.33
Seed (SEED)	0.198***	0.035	5.66
Technical Inefficiency Model			
School year (YEAR)	-0.018	0.056	-0.32
Land size (SIZE)	0.022	0.018	1.22
Plots (PLOTS)	0.213	0.130	1.63
Irrigation (IRRI)	-0.612	0.387	-1.58
Agricultural Extension Services (AES)	-0.818***	0.304	-2.69
Credit (CREDIT)	0.049	0.040	1.23
Distance to market (DIST)	-0.375**	0.167	2.24
Township 1 (TFE1)	37.629	840.11	0.04
Township 2 (TFE2)	1.341*	0.733	1.83
Township 3 (TFE3)	1.217	0.773	1.57
Township 4 (TFE4)	-4.503**	2.110	2.13
Township 5 (TFE5)	0.135	0.769	0.18
Township 6 (TFE6)	-2.538**	1.063	2.39
Log–Likelihood	-1892.36		
Mean technical efficiency (%)	0.85		
Number of observations	634		

Note: *, ** and *** correspond to statistical significance at 10%, 5% and 1% levels respectively.

2.6.3 An analysis of the impact of credit on production efficiency with the holding of different land sizes

The result of the main model shows a negative effect of credit on rice production in the selected region. This section investigates the impact of credit on farm productivity on the basis of their landholding size. In this study, it was found that farmers could not receive the credit in excess land size larger than 10 acres (nearly 4.05 hectare), as farmers could seek loans from the MADB for a maximum of 10 acres. In the selected region: 221 farm households had more than 10 acres of land whereas 413 farm households did not. The results for the stochastic frontier production model and the technical inefficiency models for farms with more than 10 acres of land and less than 10 acres of land are shown in Table 2.6 and Table 2.7 respectively.

In Table 2.6, the coefficients of land, and the expenditure on seed are significant at the 1 per cent level, while the coefficients of labour is significant at the 10 per cent level. However, it does not show any effect of inputs on rice production, as the coefficient of inputs is very small and not significant for farms with larger than 10 acres of land. Similarly, the dummy variable for the region has the negative and significant sign as unexpected. But the result of region is consistent with the main specification model I. The result shows a strong impact of region difference on rice value for farms with holding more than 10 acres of land size. Out of 221 farm households, 14 per cent of farm households from the Dry Zone (Sagaing Region) had larger farms. Farmers with holding large size of land in Sagaing are more efficient than that of those farms in the Delta Region.

The results of average schooling years, number of plots, irrigation and distance to markets from a nearby town do not show their impact on rice production for large farms. The coefficient of land size is negatively related with the production inefficiency, indicating the advantages of larger farm size for rice production efficiency. The result of access to AES shows a positive impact on production efficiency. The coefficient of credit is negative and it has a significant effect on production inefficiency, showing that farms could reduce their inefficiency if they had access to more credit. This result strongly confirms that farms with holding 10 acres of land can increase their production efficiency if they can have more available credit.

Table 2.6 Stochastic Production Model for farm households with > 10 acre

Variables	coefficient	standard error	t-ratio
Stochastic Production Frontier			
Constant	4.987***	0.359	13.89
Land (LAND)	0.630***	0.094	6.73
Capital (K)	0.001	0.003	0.22
Labour (LAB)	0.109*	0.059	1.84
Inputs (INPUTS)	0.005	0.003	1.59
Seed (SEED)	0.230***	0.047	4.92
Region (REGION)	-0.362***	0.080	-4.53
Technical Inefficiency Model			
Constant	1.746**	0.800	2.18
School year (YEAR)	-0.061	0.039	-1.56
Land size (SIZE)	-0.051***	0.022	-2.37
Plots (PLOTS)	0.078	0.097	0.81
Credit (CREDIT)	-0.142**	0.065	-2.20
Irrigation (IRRI)	-0.218	0.402	-0.54
Extension Services (AES)	-0.563***	0.257	-2.19
Distance to market (DIST)	-0.135	0.145	-0.93
Log–Likelihood	-64.49		
Mean technical efficiency (%)	0.80		
Number of observations	221		

Note: *, ** and *** correspond to statistical significance at 10%, 5% and 1% levels respectively.

However, the coefficient of distance to market does not have a significant impact on productivity. In this group, the average distance from village to market is 6 km and 50 per cent of 221 sampled farm households are closer to the markets. The mean efficiency of 0.80 suggests that farm households with larger land sizes can increase production efficiency. Overall, the findings show that farmers with larger farms, and better access to extension services could increase their efficiency if they had more credit.

The results for farms with landholdings up to 10 acres are shown in Table 2.7. The positive and significant coefficient of labour strongly confirms that farm households with smaller land sizes had a labour-intensive practice for rice production. The coefficient of capital shows no significant effect on rice production. The coefficient seed shows a positive relationship with rice production.

Table 2.7 Stochastic Production Model for farm households with $\leq$ 10 acre

Variables	coefficient	standard error	t-ratio
Stochastic Production Frontier			
Constant	4.526***	0.245	18.47
Land (LAND)	0.576***	0.075	7.72
Capital (K)	-0.002	0.005	-0.37
Labour (LAB)	0.118**	0.038	3.08
Inputs (INPUTS)	0.007*	0.004	1.89
Seed (SEED)	0.259***	0.044	5.83
Region (REGION)	-0.117**	0.056	-2.02
Technical Inefficiency Model			
Constant	-0.204	0.567	-0.36
School year (YEAR)	0.009	0.039	0.24
Land size (SIZE)	-0.185***	0.058	-3.20
Plots (PLOTS)	0.078	0.093	0.84
Credit (CREDIT)	0.066***	0.026	2.48
Irrigation (IRRI)	-1.320***	0.225	-5.87
Extension Services (AES)	0.039	0.202	0.19
Distance to market (DIST)	0.185*	0.104	1.78
Log–Likelihood	-205.223		
Mean technical efficiency (%)	0.70		
Number of observations	413		

Note: *, ** and *** correspond to statistical significance at 10%, 5% and 1% levels respectively.

The results are consistent with the main specification model I. The coefficients of land, labour, the expenditure on inputs and seed are positive and have significant effect on rice production. The coefficient of regional difference demonstrates the benefit of growing rice in the Dry Zone. Out of 413 farm households, 43 per cent and 57 per cent of farm households are located in the Dry Zone and the Delta Region respectively.

The results for farm size and access to irrigation have a negative impact on technical inefficiency. These results are similar to the results of main model specification. It is not surprising to find the evidence of little impact of plots on production efficiency. Approximately 70 per cent of the 413 farm households have only 1 plot for their farm size, while only 4 per cent have more than 3 plots for their landholding size. However, the coefficients of the number of plots and AES are not statistically significant. Nearly half of the sampled households have no access to agricultural extension services (AES) in this group. The result cannot strongly confirm whether there is a significant effect of AES on rice production.

The positive and significant coefficient of distance to market shows that the longer the distance, the higher the inefficiency of production. On the other hand, the coefficient of credit shows that it has a negative impact on technical inefficiency suggesting farmers could not increase their productivity even if they had access to credit. However, the mean efficiency of this group is 0.70, suggesting that these farm households could increase their productivity through mechanization, efficient use of inputs, access to agricultural extension, education and training.

2.7 Conclusion

Although Myanmar has the potential to increase its rice productivity, rice production has been constrained by several factors. This study has investigated the key factors that determine the productivity and efficiency gains in rice production, especially in the selected regions of Myanmar. The endogenous stochastic production function has been applied to investigate the production efficiency with or without control for township fixed-effects.

The effect of labour is statistically significant, suggesting that rice production in Myanmar is still labour intensive. There is little impact of capital on rice production. Farm households are likely to increase their rice value if they use fertilizer and pesticide effectively. Overall, better education of household members who are engaged in farming activities has a positive effect on production efficiency, showing that large farm household with better education of household farm labours are likely to increase their productivity. The study also confirms that agriculture extension services, such as education and training, are important for improving rice productivity and rural income.

The impact of credit on the rice production of large farms highlights the fact that those farm households improve the efficiency in rice production if they have access to more credit. Farmers rely heavily on loans from the MADB, which charges the lowest interest rates compared with other financial institutions. The study found that farm households with better irrigation had higher productivity in the selected areas. Surprisingly, the study finds that a longer distance to market has no influence on farm's total value of rice production. There is a need to use fertilizer systematically with the provision of services by the Myanmar Agriculture Services (MAS). The Government of Myanmar should prioritise investment in research, training, and agricultural extension services. Also, the findings suggests that the government should consider careful provision of credit to farmers, and take measures to improve the efficiency of rural credit markets.

In summary, the study shows that Myanmar can increase its rice farming productivity through measures such as expanding dry season irrigation, greater use of fertilizer, use of modern technology, and further developing rural infrastructure. However, there are some limitations in this study that should be considered for future research. First of all, although the number of plots is used to measure the impact of land fragmentation, the distance from homestead to each plot should be considered. Second, the impact of land use certificates could not be taken into account in this paper. The government of Myanmar has started to issue the land use right certificate after the introduction of new land policy in 2012. Some farm households in the selected areas were in the process of applying for new land use rights certificates, some areas were not being proceeded yet during the survey period. The effect of land use certificate, therefore, was excluded to study its effect on rice production to avoid incomplete information. It is important that the impact of land use certificates under the new land policy on productivity should be further considered in any future study.

2.8 Appendix : An analysis of rice production in Myanmar and Vietnam

2.8.1 Introduction

Myanmar and Vietnam share some similarities when it comes to rice production. Although Myanmar and Vietnam grow a range of crops, rice is the most important crop in between countries, being a staple food and a major source of foreign exchange. The area under cultivation is similar: 7.05 (million ha) and 7.60 (million ha) respectively [1]. The proportion of their population living in rural areas is 75 per cent in the case of Myanmar (Kyaw, 2009), and 73 per cent in the case of Vietnam (Kompas et al., 2002). Rice production contributes nearly 80 per cent to the value of agricultural produce in Myanmar (ADB, 2013), and 90 per cent of grain output in Vietnam (Kompas et al., 2012). The contribution of rice to rural households for both countries is quite similar: approximately 67 per cent of rural income in Vietnam comes from rice production and nearly 75 per cent of rural income in Myanmar (Kompas et al., 2012; Wong and Wai, 2013). The contribution of primary income from agriculture in rural household income in Vietnam significantly declined from 43.4 per cent in 2002 to 31.8 per cent in 2012 (Jaffee et al., 2016).

However, the trajectories of rice production in two countries are in marked contrast. There are differences between the two countries, especially in terms of government policies and institutions. Myanmar was one of the world's largest exporting countries of rice in the late 1930s and early 1940s (Thein, 2004). During this period, Myanmar exported approximately 3 million tons of rice (60 per cent of its total crop), mainly to Europe, India and Sri Lanka. However, since the early 1960s under the "Burmese Way to Socialism" (1962-1987), Myanmar's position has fallen, and it now ranks the world's sixth-largest rice-exporting country. In the case of Vietnam, rice production has been dramatically increasing since the introduction of the *Doi Moi* reform in 1986. It now ranks the world's third-largest rice exporter after India and Thailand with the annual exports of over 5 million tons, in spite of its being a rice-importing country in the 1980s (Kubo et al., 2013).

In 2013, the average annual yield of Myanmar was 3 tons per hectare, while Vietnam was over 5 tons per hectare (Kubo et al., 2013). Indeed, the average

[1] The data is drawn from the World Rice Statistics online website (http://ricestat.irri.org:8080/wrs/ Accessed on May 15 2015).

annual yield of Myanmar is the second lowest of the ASEAN countries, including Thailand, Philippines, Indonesia and Malaysia (Raitzer et al., 2015). Wong and Wai (2013) have mentioned the cost of milling, loading and transportation that is relatively high in Myanmar compared to other Asian countries. According to Fujita et al. (2009), the main reason for the stagnant average yield in Myanmar was the low rice price policy by the state. Furthermore, Kubo et al. (2013) also explained that the annual average yield per hectare is the major reason of the difference in rice production between Myanmar and Vietnam. They suggested that an effective investment in production technology could improve the rice yield level in Myanmar.

In addition, Vietnam uses more labour intensive than Myanmar, and Vietnamese farmers are more educated compared to those of Myanmar. The agriculture sector employs 63 per cent of the labour force in Myanmar (FAO, 2016) that is relatively lower than that of Vietnam. Vietnam has been found to be more labour intensive compared to Myanmar as over 70 per cent of population is involved in the agricultural sector (Tran Toan Thang, 2014). The other factor is the educational level of farmers. Myanmar 's farmers are lack of knowledge and less educated than other countries in the region. The literacy rate in rural area of Myanmar accounts for 84 per cent (Zorya, 2016). In contrast, the literacy rate in Vietnam 's rural area is 88.7 per cent. It is worthy to note that the definition of literacy used in Vietnam differs from the definition in other studies. The Government of Vietnam has introduced the first campaign of literacy in 1954 (Phan et al., 2004). A person is defined as literate when he or she has completed at least grade 5 (primary education from grade 1 to 5). In this case, farmers in Vietnam are found to have better educational achievement.

Previous studies on the difference in rice production performance mainly focused on the difference in rice yields, pricing policies and investment in technology between the two countries. The purpose of this paper is to show that how different government policies could lead each country to different positions in terms of rice production and rice yield. This paper has two parts. The first part discusses the background of agricultural reforms including land policies, land reforms and market reforms due to difference in experience, especially nature of land policy between these two countries. The second part examines the impact of government policies including fertilizer, credit and irrigation infrastructure. The structure of this paper is as follows: Section 2.8.2 discusses the background of agricultural reforms and rice production in the two countries.

Section 2.8.3 gives the overview of rice production. Section 2.8.4 demonstrates an average yield per hectare between Myanmar and Vietnam, section 2.8.5 discusses the government policy on agricultural inputs. Section 2.8.6 and 2.8.7 cover the credit policy and investment in irrigation infrastructure. Section 2.8.8 analyses the cropping intensity and Section 2.8.9 presents the conclusion.

2.8.2 Background to Myanmar and Vietnam

Given the importance of rice production, the governments of both Myanmar and Vietnam have implemented various programs and policies to improve rice production, especially land reforms and market reforms. However, the reforms in Vietnam including Laos introduced more than 20 years before Myanmar started its reforms (Odaka, 2015). Myanmar introduced its first agricultural reform in 1987, and its market reform in 2003. In 2012, Myanmar launched its Farmland Law and the Vacant, Fallow and Virgin land Management Law. Vietnam launched output share contracts in 1986, and trade liberalization in 1988. This section explains how these reforms helped both countries to increase rice production.

Agricultural reforms in Myanmar

Prior to 1953, residents and non-residents in Myanmar had the right to own agricultural land. However, in 1953, the government of Myanmar established the Land Nationalization Act. The objective of this policy was to nationalize land ownership by non-residents who had large land holdings during the British Colonial period. Under this policy, all farmlands were changed from private ownership to state ownership. The state became the ultimate owner of land and redistributed all agricultural land to farmers (UNHCR, 2011). Farmers did not have the property rights for land as all farmlands were totally controlled by the government. Instead, farmers were required to apply for an annual renewal of the tillage rights, meaning that none of them had permanent rights to hold and/or rent the land to the other people.

There was also a strict restriction to the transfer of tillage rights for the purposes of sale, lease and mortgage of land. The maximum limitation of land holding for each farm household was 50 acres (approximately 21 hectares) (Okamoto, 2005). Indeed, the government redistributed agricultural land that exceeded the maximum limits to tenant farm households followed by owners of small land and landless labours. However, there was no equal distribution of land tillage rights among rural farmers. Most rural farm households, in particular, over 61 per cent worked on farms with less than 5 acres.

The period 1962-1988 was known as the socialist regime period in Myanmar. From 1962-1973, there was no significant improvement in the agricultural sector, specifically as regards with technology, production levels, and research and development. In 1963, the Land Tenure Law and Rules were enacted to protect a farmer's right from land confiscation. This law was replaced by the Tenancy Law of 1965, under which farmers received the right to work (Thein, 2004). In 1972-1973, the government of Myanmar (GOM) launched the Whole Township Rice Production Program (WTRPP) to increase rice production through using chemical fertilizer and high-yielding variety (HYV) seeds. As a result, the growth rate of rice production increased between the mid-1970s and early 1980s.

In 1974, the government launched the sales of fixed quotas of food grains and a compulsory delivery quota system to the state. Farmers had to sell a fixed quota of paddy to the state at a fixed procurement price that was half of the prevailing market price. The remaining amount of paddy could be sold to Trade Corporation No.1 (later changed to Agricultural Farm Product Trading Corporation (AFPTC)) within the township (Hudson-Rodd et al., 2003). If farmers could not fulfil the requirement of either the quota system or the cropping system, they could lose their land tilling rights. During this period, no private sector was allowed to trade agricultural products domestically or internationally.

In September 1987, the first agricultural reform was implemented to develop the agriculture sector. The government lowered the quota amount for paddy. Farmers could sell the remaining paddy to four major agents at market prices. In September 1988, the military regime government lifted restrictions on the private export of some agricultural crops, such as black gram, green gram, maize and pigeon pea. However, rice remained under the control of the state through the Association of Myanmar Agricultural Produce Trading (MAPT).

To further increase the production of rice, the summer paddy program (SPP) was initiated in 1992-1993. Under this program, farmers could cultivate a second rice crop using irrigation facilities. In 2003, the government launched a new policy, to so-called 'second agricultural reform', ending the old procurement system and liberalizing domestic and export markets for agricultural products. Farmers could freely decide which crops they grew and to whom they sold their produce. The inputs, including fertilizers, pesticides and seeds, which were initially distributed by the MAS, were transferred to private sectors (Thein, 2004).

The government of Myanmar (GOM) enacted the 2012 Farmland Law to fulfil the objective of securing access to land for rural development. Farmers could now have land use certificates with no limitation on holding land size as long as they did not breach the rules. Under this framework, farmers had more freedom to choose appropriate crops to sell or transfer, or they mortgage or rent their land use rights to other people. As a result of this new policy, farmers could manage their land resources more effectively and improve production efficiency (Department of Agricultural Planning, 2013b).

Agricultural reforms in Vietnam

Land tenure was collectivised between 1955 and 1988 in Vietnam (Men et al., 1995). During the French Colonial period, French plantation owners and large Vietnamese landlords occupied most of the farmland. In the mid-1940s, only 3 percent of the indigenous people owned 52 percent of the land, and over 60 percent of farmers were landless.

After independence of the country from the French in 1954, the country was divided into two parts, North and South. Land reform was first carried out in the North by distributing land and ownership rights. Due to this reform, agricultural outputs and productivity rapidly increased. However, the policy of land collectivization was introduced in the late 1950s. Under this policy, 90 per cent of paddy farmers worked in cooperatives by the mid-1960s. Individual farm household held only 5 percent of farmland, and earned 60 to 70 percent of their income from small plots (Cotula, 2009).

In the South, the government introduced the Land-to-the-Tiller Law in 1970, when it started the war with North Vietnam. Cultivators were provided with the ownership rights, while landlords were allowed to hold no larger than 20 hectares. After the end of war in 1975, land collectivization was introduced in the South. All farms activities were chosen by the State under the commune system (1975-1980). During this period, farm households just received a share of production depending on their working hours in the communal land. A portion of rice had to be delivered to the state for which farmers did not receive any money. Farmers had to sell the remaining part of their produce to the state at 20 to 30 per cent of the prevailing market prices. As a result of its output control system, Vietnam imported rice from the Soviet Union between 1977 and 1980.

In 1981, Vietnam moved away from a de-collective agriculture system. In 1986, farm households could keep the surplus of output they produced after they reached the contract output. Under this system, farmers still had to sell about 80 per cent of their output at low state prices, and could sell only the remaining 20 per cent in private markets at the prevailing market prices (Kompas et al., 2002). The agricultural production was very low until 1985, and the country became an importer of rice. Between 1981 and 1987, the Communist Party of Vietnam (CPV) launched market reforms by designating the output contracts to develop the agriculture sector. In December 1986, the CPV introduced the program of *Doi Moi* and liberalized the economy. This reform introduced the effective property rights for both land and capital equipment. Farmers could freely sell their rice in private domestic markets and international markets.

In 1988, the CPV launched a new Land Law (Resolution 10) that expanded land use rights to households for 10-15 years, although land remained under state ownership (Marsh et al., 2006). Farmers were not allowed to trade, rent or alter use or agricultural land. In 1989, the CPV moved to a market economy, including rice and chemical fertilizer, and it decentralized production decisions. As a result of these reforms and trade liberalization, there has been a higher growth rate of rice output since 1986. Annual production increased by 26.1 per cent, while the annual rice yield increased by 29.6 per cent between 1989 and 1992. Vietnam started exporting rice in 1989 and become the world's second largest rice exporters (Kompas et al., 2002).

The CPV established the new constitution and amended the 1988 Land Law, namely the 1993 land law. Under this law, land use rights were extended to 20 years for annual crops (initially 10 to 15 year) and 50 years for perennial crops (Marsh et al., 2006). In addition, the land use certificates (LUCs) were issued under the implementation of the law. Farmers were required to first apply for the LUCs through the commune level People's Committee. Second, the Land Registration Committee distributed the application forms for land registration to land users in the commune. To avoid the dispute about claim on land, it was necessary to have the signatures of both land users and all neighbouring households on this form.

The Land Registration Committee checked these forms and decided to issue the LUCs to eligible land users. Farmers could transfer, exchange, rent, inherit, and mortgage land. Land holdings, however, were still limited to 2 hectare per household in northern and central provinces, and 3 hectare per household in southern provinces (Government of Vietnam, 1993). In 2001, the government revised the Land Law, and allowed commune authorities to undertake the plan of land used, allocation of land and the approval of land changes. These land reforms brought the improvement of land policy and development of land markets. In 2007, the government increased the ownership of land size from 3 to 6 hectare in the South East, MRD and Ho Chi Minh, and from 2 to 4 hectare in other cities and provinces (Kompas et al., 2012).

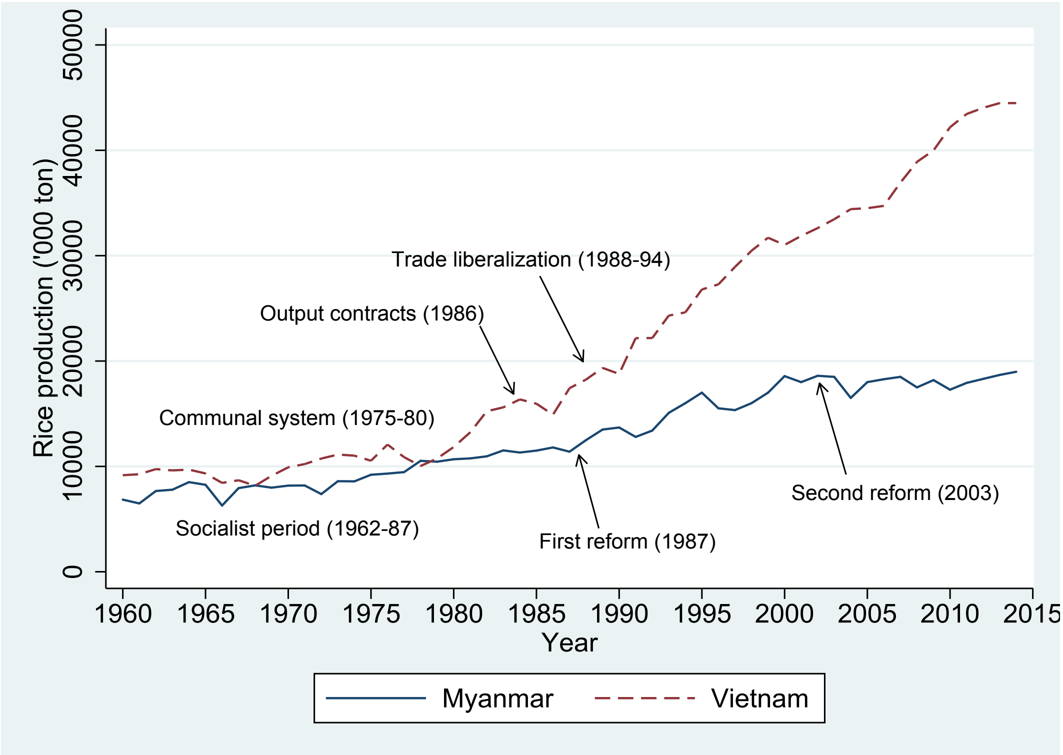
2.8.3 An overview of rice production of Myanmar and Vietnam

Annual rice production of Myanmar and Vietnam

Rice production trends in Myanmar and Vietnam can be broken down into two periods for each country: (i) 1960-1986 and (ii) 1987-2014 for Myanmar, and (i) 1960-1980 and (ii) 1981-2014 for Vietnam. In 1987, the Government of Myanmar introduced its agricultural market reform. 1986 was also distinct in Vietnam as the CPV changed the contract system to a household-specific production quota.

The data for rice production can be drawn from two sources: the Food and Agriculture Organization (FAO) and the United States Department of Agriculture (USDA). According to Odaka (2015), there was a large gap in data between the two sources, especially in Myanmar, since the introduction of "All Township Special Rice High-Yielding Varieties Production Program" in the late 1970s. During the period of the late 1970s to the early 1980s, the average yield in Myanmar was found to sharply increase from 2 to 3 tons per hectare (Odaka, 2015). The author argues that the data from the USDA is much more reliable than that from FAO that estimates based on the official statistics of Myanmar Government. In this review, therefore, the data from the USDA is mainly used to analyse for rice production and annual yield per hectare between two countries.

Fig. 2.1 The trend of rice production in Myanmar and Vietnam



Source: USDA data access from IRRI Statistics database

Figure 2.1 shows the trend of rice production in both Myanmar and Vietnam from 1960 to 2014 using the data from USDA source. Rice production had a lower growth rate under the socialist period (1962-1988) in Myanmar, and the communal system (1975-1980) in Vietnam. Between 1960 and 1980, Vietnam's rice production was slightly higher than that of Myanmar. Rice production of Vietnam, however, has dramatically increased since 2000. According to USDA statistics, it was around three times higher than that of Myanmar between 2007 and 2014. In this regard, cropping intensity should be taken into account as one of the important factors for both countries.

The cropping patterns in Vietnam are classified into dry season (spring), dry season (autumn) and wet season (winter), whereas triple cropping is applied in some areas of the country. The spring and winter seasons produce approximately 50 per cent of total production (De Luna-Martinez and Anantavrasilpa, 2014). In contrast, Myanmar paddy is mainly planted in monsoon season (May to November) and the winter season (December to June). More than 70 per cent of total rice production comes from the wet season, while only 8 per cent derives from the dry season (World Bank, 2014). Now this review will look at the rice production trend for each country.

During Myanmar's socialist period (1960 to 1986), farmers had little incentive to increase production, as the quota amount was based on their cultivated land size and yields (Thein, 2004). The rice production trend remained stable between 1962 and 1987. Production fell between 1966 and 1968 because of a severe drought (Soe and Fisher, 1990). Due to the severe effect of monsoon, rice production significantly fell again in 1972 and 1973 (Win, 1991). As a result of the WTRPP program, rice production markedly increased at an annual growth rate of 6.35 per cent between 1975 and 1980 (Thein, 2004). There was a dramatic increase in rice production from 8.448 million tons in 1974-75 to 14.146 million tons in 1982-1983 (Soe and Fisher, 1990).

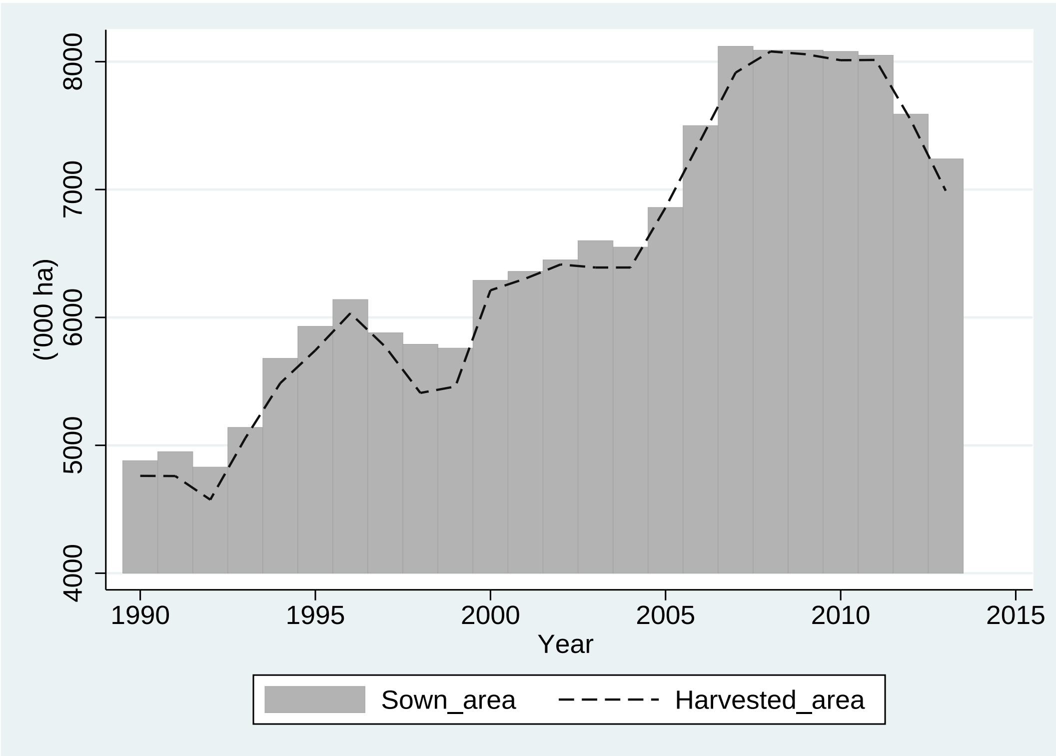
Rice production increased gradually after the government launched the first agricultural reform in September 1987 that permitted free domestic markets, lifted price controls, and reduced delivery quotas to 10-12 baskets per acre (0.5-0.6 tons per hectare) (Okamoto, 2005). Due to the SPP program in 1992-1993, rice production dramatically increased until 1996. However, major floods between 1996 and 1997 caused rice production to fall sharply. In 2003, the second reform abolished the procurement system. The two reforms and the SPP helped increase rice production from 11.4 million tons in 1987 to 18.98 million tons in 2014. This growth came mainly from the SPP with an expansion of irrigated land. In 2008, rice production declined as a million acres of rice paddy fields were affected by Cyclone Nargis.

In the case of Vietnam, the quota system and price policy discouraged farmers from producing effectively or using resources efficiently which resulted in the lower growth rate of production between 1960 and 1980. After the introduction of an output contract system in 1986, farmers could freely sell their output after they contributed the set quota of paddy to the state. Due to the trade liberalization in 1988, rice paddy could be sold freely in the competitive domestic markets. As a result of reforms, there was a significant growth in rice production with the expansion of dry season cropping. As shown in Figure 2.1, the annual production increased from 13.24 million tons in 1981 to 44.48 million tons in 2014.

Sown areas and harvested areas in Myanmar and Vietnam

In general, an increase in both cultivated areas and annual yield are also important factors determining the growth of annual rice production (Kubo et al., 2013). The sown area of both countries gradually increased throughout the period. Figure 2.2 and Figure 2.3 show the total sown area and harvested area of Myanmar and Vietnam between 1990 and 2014 [2].

Fig. 2.2 Sown area and harvested area in Myanmar



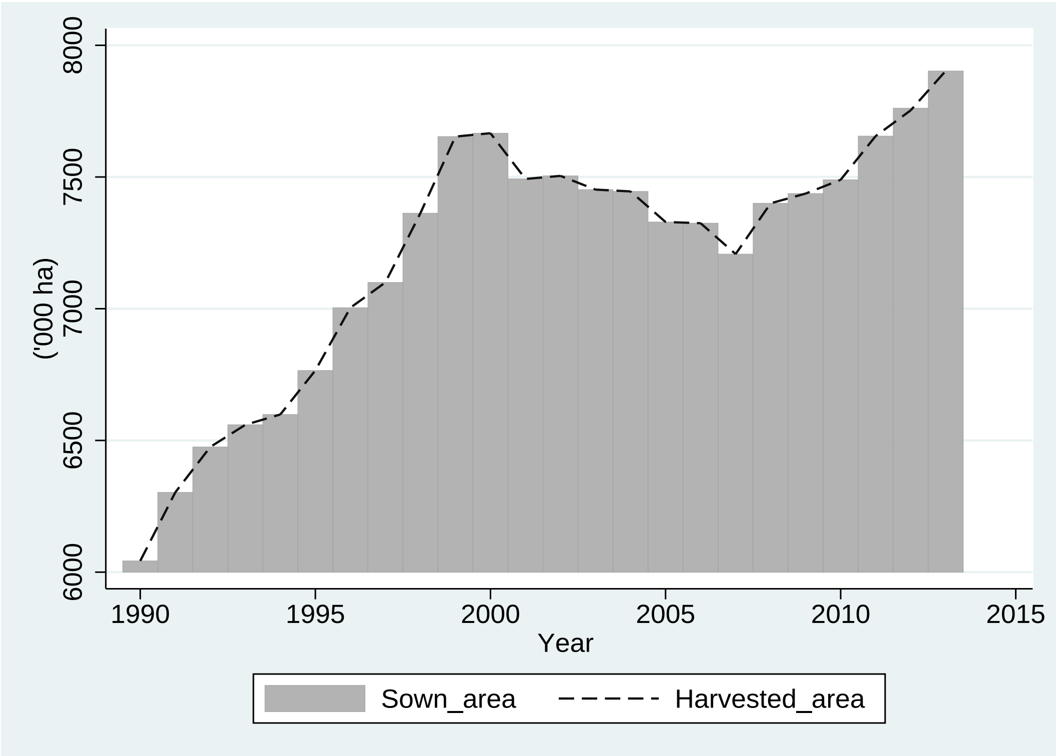
Source: Ministry of Agriculture and Central Statistical Organisation, Myanmar

Figure 2.2 shows that the GOM expanded land area under cultivation, with the WTRPP in 1971 and the SPP in 1993. As a result of the land expansion, the areas sown with high yield varieties increased by 66 per cent from 1972 to 2013. Overall, the available sown area rapidly increased from 7.39

[2]Since the data set for sown area and cultivated area for Myanmar is unavailable on either USDA or FAO sources. There has been a concern over the quality of agricultural statistics by Government of Myanmar (Odaka, 2015), but this is the only source that has available information on sown areas and harvested. The data used in Figure 2.2 is drawn from Ministry of Agricultural and Central Statistical Organization, Myanmar. In the case of Vietnam, the sown area is drawn from FAO, while the harvested data is drawn from General Statistical Office, Vietnam.

million hectare in 2006 to 8.05 million hectare in 2011, although it fell slightly afterwards. Approximately, 90 per cent of sown areas were harvested in Myanmar.

Fig. 2.3 Sown area and harvested area in Vietnam



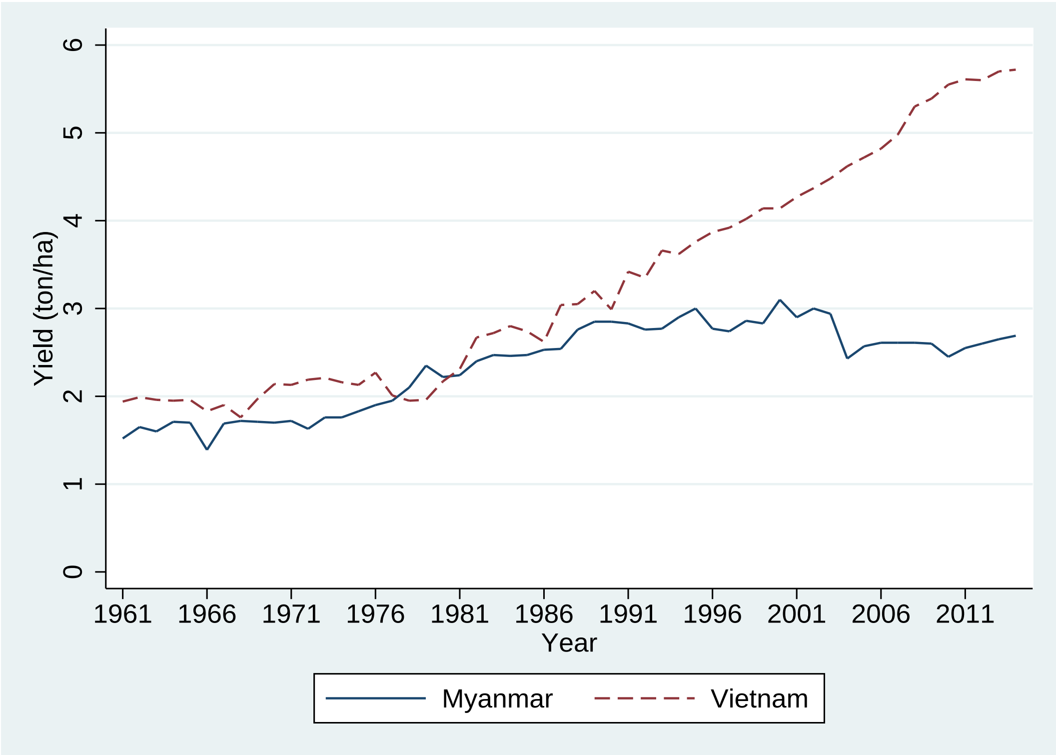
Source: FAO and General Statistical Office of Vietnam

In Vietnam, the sown areas significantly increased after the implementation of the output contract system. The net cultivated area in Vietnam increased by 40 per cent from 1981 to 2014 as a result of its reform process. As is seen in Figure 2.3, there was a decrease in sown areas between 2001 and 2007. Similar to Myanmar, approximately 90 per cent of sown areas have been harvested in Vietnam.

2.8.4 An average yield per hectare between Myanmar and Vietnam

Figure 2.4 shows the average yield of Myanmar and Vietnam between 1961 and 2013. Although the annual yield of paddy (ton per hectare) in Myanmar was lower than that of Vietnam between 1961 and 1981, the difference was not significant.

Fig. 2.4 Annual yield per hectare in Myanmar and Vietnam



Source: USDA data access from IRRI Statistics database

The average yield per hectare in Myanmar under the procurement system was steady at around 2 tons per hectare. As a successful program (WTRPP), the average yield per hectare significantly increased between 1978 and 1983. The average yield has been stagnant at 3 tons per hectare since 1995, although the second market reform was launched in 2003. This amount of yield is the lowest level of output among ASEAN countries (Dawe, 2013).

Vietnam's annual yield per hectare has been sustained for more than 20 years. Prior to 1981, the average yield was 2.17 tons per hectare, gradually rising to 3.04 tons per hectare in 1987 after the output contract system was implemented. This amount of yield dramatically increased following the introduction of trade liberalization in 1988. The average yield rose from 3.05 tons per hectare in 1988 to 5.72 tons per hectare in 2014. As is seen in Figure 2.4, the gap in yield level between the two countries has been large since the early 1990s.

2.8.5 Agricultural inputs policy

Fertilizer Consumption in Myanmar and Vietnam

1. Myanmar

The use of fertilizer is a major determinant of yield in rice production. During the socialist period, the Procurement and Distribution of Inputs Subcommittee was mainly responsible for the distribution of agricultural inputs including fertilizers and pesticides, and quality seeds to farmer at subsidized prices (Win, 1991). However, the government could provide only 20 per cent of the required amount of fertilizer. The government stopped subsidizing inputs after 1995-1996, and transferred responsibility to the private sector for the distribution of these inputs. After 1997, state agencies were allowed to import and distribute chemical inputs (Thein, 2004).

In 2002, the government introduced the fertilizer law and regulations, under which private companies could produce, import or export fertilizer. However, those companies needs a registration certificate, which is issued by the Fertilizer Committee (Food Security Working Group, 2015). The government does not set the price for, or distribute, fertilizers, and does not impose import tariffs on agricultural inputs. Domestic producers could not meet the demand for fertilizer due to a shortage of raw materials to produce fertilizers. Myanmar fertilizer markets heavily rely on imports accounting for over 80 per cent of total market demand or approximately 1.2 to 1.4 million tons per annum (Gregory et al., 2014).

Fertilizer is imported mostly from China. The number of registered fertilizer importers and distributors were 270 in 2014 (Gregory et al., 2014). About 90 per cent of fertilizer is imported by the large majority of those companies. Wholesalers and retailers usually make a profit of 25 to 40 per cent on the sale of fertilizer. Therefore, prices of fertilizer increase at a faster rate than the prices of rice that leads to the inefficient use of inputs in paddy production. In addition, farmers purchase fertilizer from traders at 3 to 5 per cent of the interest rate per month for credit-based sales (Lwin et al., 2014).

The high price of fertilizer and interest rates push up production costs, and then decrease farmer's income. Farmers cannot use the optimum amount of fertilizers due to limited working capital, insufficient credit amount and higher interest rate in informal credit markets. The use of fertilizer per hectare remains still low where compared with neighbour countries. In particular, the application of chemical nutrient fertilizer in Myanmar is just 10 per cent of that for other South Asian countries and less than 7 per cent of that for Vietnam. The use of fertilizer increased by 25 times from 1960 to 1985, however, the application rate of fertilizer per hectare is still relatively low (Win, 1991). The average amount of fertilizer in Myanmar was 15.7 kg per hectare in 2012 (World Bank, 2015), while it was 190 kg per hectare [3] in Vietnam.

2. Vietnam

During the period from 1960 to 1989, the Vietnamese government controlled production, import and distribution of fertilizer. Initially state production could not satisfy the local demand of fertilizer. The shortfall was met by imports, on which no taxes were levied. Similar to Myanmar, chemical fertilizers were heavily subsided to promote rice production during this period in Vietnam. The use of fertilizer increased rapidly from 57 kg per hectare (0.376 million tons in total) in 1983 to 85 kg per hectare (0.544 million tons in total) in 1990, in which 80 per cent of fertilizer was used in rice production.

From 1990 to 2000, the government partially liberalized and encouraged private sector investment in the fertilizer sector. Fertilizer use was 180 kg per hectare in 1996, more than double the usage in 1990 (Minot and Goletti, 2000). In 2000, price controls were abolished. Fertilizer production grew significantly, Vietnam became a fertilizer exporter. The increase in domestic fertilizer production together with multiple cropping intensity are the major reasons for the rapid increase in fertilizer use.

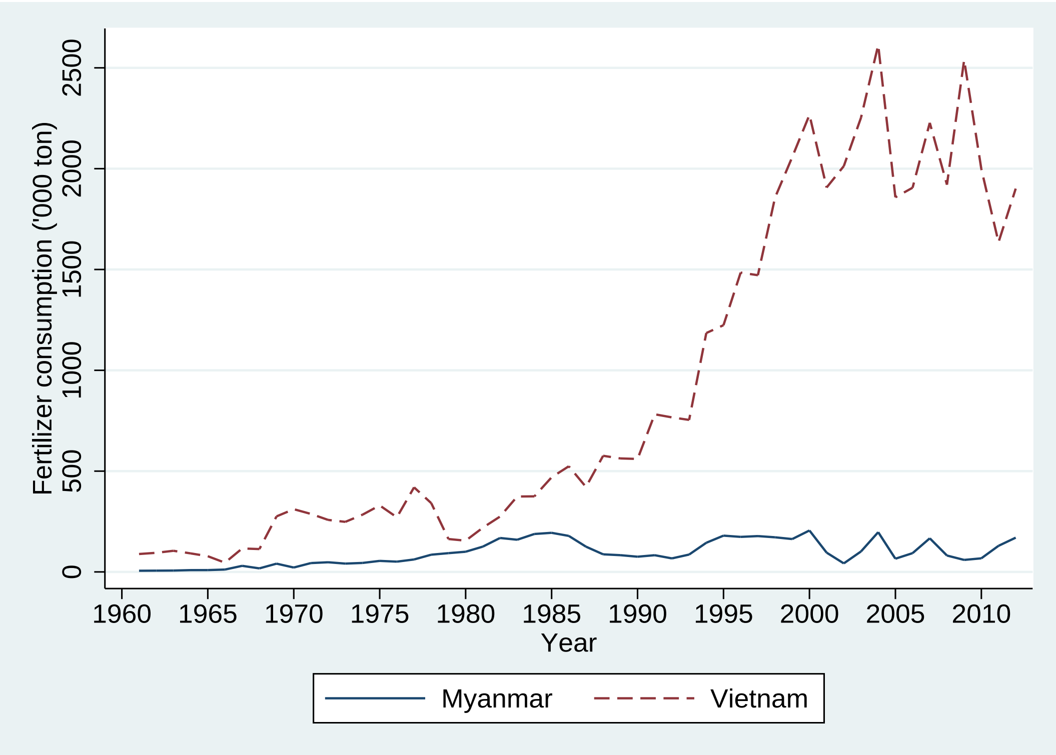
Figure 2.5 illustrates the application rate of fertilizer in both countries from 1961 to 2011 [4]. The gap in fertilizer application between Myanmar and Vietnam started in the early 1990s. It is not surprising that there had been a widespread use of fertilizer in Vietnam, after the output contract system. In Myanmar, the use of chemical fertilizers started in 1957, and increased at a steady growth rate of 10 per cent until 1970. The total value of fertilizer consumption of Myanmar was 170.07 ('000 ton), while that of Vietnam was 1901.12 ('000 ton) in 2012. The use of fertilizer in Vietnam has been higher

[3] The use of fertilizer was 297 kg per hectare as reported by The World Bank.

[4] Since the data set for fertilizer is unavailable on the USDA source, the data used in Figure 2.5 is drawn from the FAO data access.

than that of Myanmar throughout the period (Tran Toan Thang, 2014).

Fig. 2.5 Fertilizer consumption in Myanmar and Vietnam



Source: FAO data access from IRRI Statistics database

Seed distribution in Myanmar and Vietnam

1. Myanmar

The Myanmar Agriculture Services (MAS) under the MOAI provides extension services and seed multiplication, promotes hybrid rice seed, and undertakes agricultural research and development and plant protection (ADB, 2013). Although the Department of Agriculture (DOA) has initiated programs to produce and distribute certified seed since 1987, lack of funding has restricted its research into new seed varieties. The government of Myanmar has introduced the Seed Law in 2011, and managed the rules for seed breeding, production, registration, and quality control. This law encourages the private sector and non-government organizations (NGO) to engage in the development of seed production, and cooperate with other international organizations. In 2004, the National Seed Committee (NSC) has been established to take responsibility for the quality assurance of seeds throughout the country.

The seed sector can be designated by three different systems. First, the informal seed system in which most farmers reproduce their own seed from previous harvests. Over 95 per cent of seed including rice used by farmers mainly comes from the informal seed system. Second, the intermediary seed system in which improved varieties are produced by individual private seed growers and private seed companies. The third one is formal seed system in which private companies produce the developed varieties, import and marketing of seeds (Department of Agriculture, 2016). However, the formal seed system is able to supply less than 5 per cent of the quality seed demand of farmers. The focus of quality seed production by the formal seed system is rice, followed by maize, legumes, and oilseeds (Van den Broek et al., 2015). In 2016, the government approved the Seed Policy, Seed Regulations and Plant Variety Protection Law, introduced the regulations of variety registration, seed production and business. Under this policy, new varieties of all crops need registration, and seed certification is compulsory for market sales (Department of Agriculture, 2016).

Department of Agriculture (DOA) took responsibilities for multiplication, procurement, storage, and seed distribution until 2000. The Department of Agricultural Research (DAR) under Ministry of Agriculture and Irrigation (MOAI) has become responsible for testing new varieties in research station for the confirmation of potential yield, quality, genetic stability, local adaptability and pest and disease resistance since 2000. The production of breeder and foundation seed is also the responsibility of DAR. The Seed Division of DOA produces the foundation and registered seed by using seeds made by DAR. Although the Seed Division is the responsible for certifying seeds, the procedures are not well established yet. Due to insufficient staff and facilities, seed certification (filed inspection and laboratory testing) is not undertaken properly by the Seed Division (Oo and Shwe, 2015). Van den Broek et al. (2015) also mentioned that the inefficiency in performance of seed chain, reducing the number of seed varieties demanded by farmers and overall seed quality were led by the limited communication and collaboration between the DOA's Seed Division, DOA's Agricultural Extension Division and DAR.

There are 56 research and seed farms throughout the country. The Seed Division of DOA is responsible for the supervision of 32 seed farms, while DAR has 24 research farms with a total of 450 technical people to develop hybrids of rice, sunflower, and maize. Research farms of DAR has developed 99 rice varieties and 112 crop varieties. In addition, the DAR also takes the responsibilities to maintain both 12,000 samples of local land-races and genetic seed bank for wild rice relatives. However, the major challenge for agricultural research activities is insufficient funding that accounts for only 1 per cent of total budget of MOAI in 2012-2013 (Oo and Shwe, 2015). According to the report by MOALI (2018), spending on agricultural research and development of Myanmar declined to 0.4 per cent of agricultural GDP in 2016-2017, which is the lowest ratio in the region. Spending of Vietnam on R & D takes approximately 5 per cent of total agricultural GDP that is between 5 to 10 times much higher than that of Myanmar.

After liberalization in 2000, seed distributed by public sector was replaced by a system of contract farmers and public-private partnerships, namely rice Specialized Companies (RSCs). Under this system, the procedure of registered seed production by research farms of DOA was transferred to extension agents to a total of 4,900 RCS in 530 villages with the aid of Agricultural extension Division (AED). More recently, public-private partnerships have been set up to distribute improved seed, though their distribution systems are still weak. The distribution system of certified seed covers less than 10 per cent of the estimated demand for rice and 1 per cent for other crops. This means that farmers have limited access to high-quality seed. Dapice et al. (2011) described using low-quality seed that might produce the broken rice at high proportion during the milling process. The shortage of certified seed becomes a major constraint to improve crop productivity in Myanmar.

In 2016, Ministry of Agriculture, Livestock and Irrigation (MOALI) has developed the Road Map for Myanmar Seed Sector, in collaboration with the private sector, and international organizations such as Asian Development Bank(ADB), Food and Agriculture Organizations (FAO), International Food Policy Rice Institution (IFPRI), International Rice Research Institute (IRRI) and the Netherlands Mission and United States Agency for International Development (USAID) (Department of Agriculture, 2016). The objective of Road Map is to develop a strategic agenda for the period of 2017-2020 that highlights the steps needed to transform from the current seed sector to competitive seed sector, and to fulfil the needs of farmers in Myanmar.

2. Vietnam

Vietnamese seed industry has been developed since 1960. Between 1960 and 1970, the seed industry was mainly undertaken by the public. However, private sector and foreign companies were allowed to work in the industry after the removal of output contract system in 1986. Since 1996, there has been a rapid increase in the development of industry in collaboration with public and private sectors. Over the 50 years' period, Vietnamese's seed industry achieved success including the development of crop seeds with good quality, high yielding, adaptable, and strong resistance to pests and diseases.

Between 1977 and 2005, the seed industry was able to produce 575 new crop varieties, including 177 rice varieties, and 97 varieties for other crops including maize, potatoes and cassava varieties. The adoption of modern technology including methods for fertilizer application and high-yielding rice varieties (MV) contributed to the remarkable growth rate of production and average yield per hectare. A high-yielding rice variety, IR8, was adopted in South Vietnam by Long Dinh Research Station in 1996, and in northern Vietnam in 1998. The utilization rate of MV has increased from 17 per cent in 1980 to nearly 90 per cent in 2000, indicating an increase in rice yield was largely attributable to the rapid cultivation of MV. However, high qualified seeds meet approximately 40 per cent of demand by users (Dung, 2014). The Vietnam Seed Trade Association reports that 15,000 tons of hybrid rice seed is mainly imported from China, accounting for 70 to 75 per cent of demand.

In the 1990s, the Cuu Long Delta Rice Research Institute (CLRRI), Southern Agricultural Science Institute, Plant Protection Institute (PPI), the Agricultural Genetic Institute (AGI), and the Vietnam Agriculture Science Institute (VASI) developed new and different varieties. However, the Ministry of Agriculture and Rural Development (MARD) is the key player for the management of national agricultural and forestry seed varieties. The average yield increased to 4 tons per hectare, almost double that of traditional varieties (Tran Toan Thang, 2014). It is worth noting that Vietnam's research systems for rice production have been developing the appropriate rice varieties for different ecosystem around the country (Thi Ut and Kajisa, 2006).

Due to the report of Vietnam Seed Trade Association, 415 businesses have been involved in the formal seed supply system in 2011. Of those businesses, 8 international/multinational companies produce hybrid maize, vegetable, and rice seeds. In fact, the government agencies are mainly responsible for research activities related to seed at the central level, sub-regional level and the universities. There are 6 universities and 18 research institutions that undertakes breeding and adapting improved seed across the regions in Vietnam. Of 18 research institutions, 15 institutions are under MARD. Since 2005, all research institutions have their autonomy and self-management mechanism with regard to research agenda, finances and organizational structures. Despite the policy change, MARD still plays an important role for research and development activities. MARD has approved 19 projects for seed with an investment of VND 268 billion (US$12 million), however, the supply of seeds only accounts for VND 16 billion from projects (Dung, 2014). The seed industry of Vietnam, therefore, is still highly dependent on imported seeds although formal seed system in Vietnam has many significant achievements during the period of 50 years.

2.8.6 The impact of credit on rice production in two countries

Myanmar

This section briefly discusses the current situation of agricultural loans in Myanmar. The financial service sector in Myanmar remains largely underdeveloped. The main providers of financial services are the MADB, commercial banks, cooperatives, microfinance institutions (MFIs) (PACT, Proximity, Save the Children, and World Vision), rice-specialized companies (RSCs), pawnshops, informal money lenders, unregulated input providers.

Among the formal financial institutions, MADB plays a major role in rural financial markets. PACT is the largest providers among MFIs, which services approximately 74 per cent of MFIs clients. The focus of MFIs is mainly on providing loans in towns and cities instead of rural areas. The main purpose of loans is for business or small and medium enterprises on group basis. About 19 per cent of its borrowers is provided with agricultural loans. The size of agricultural loan is 250,000 Kyat at an interest rate of 2.5 per cent per month for five months period (FAO, 2016).

The MADB provides loans for monsoon and winter paddy, and other crops. The MADB only gives loans to farmers who have a Farmer's Registration Book for land use rights and who have joined a group of 5 to 10 farmers. The MADB charges an interest rate of 8.5 per cent per annum, which is the lowest rate compared with that of other financial institutions. In June 2014, the MADB further reduced the interest rate to 5 per cent per annum (Thomas et al., 2015).

Farmers can borrow 100,000 Kyat (USD 100) per acre for paddy and 20,000 Kyat (USD 20) per acre for non-rice crops from the MADB. The maximum amount for a loan that farmers can apply from MADB is 1,000,000 Kyat (USD 1000) for a maximum of 10 acres. By contrast, the estimated cost per acre of rice is 200,000 Kyat per acre (USD 200) for low-quality rice and 400,000 Kyat per acre (USD 400) for high-quality rice. The loans from the MADB, therefore, cover only 20 per cent of the production costs (De Luna-Martinez and Anantavrasilpa, 2014). As a result, farmers mostly rely on the informal sector including friends, relatives, landlords, neighbours, money lenders, pawnshops, traders and suppliers of agricultural inputs who charge between 5 per cent to 20 per cent per month. A baseline survey results of LIFT showed that 42 per cent of its sample households borrowed from family and friends, 31 per cent from money lenders. Consequently, farmers cannot afford to purchase agricultural inputs that would result in lower productivity of rice production in Myanmar (LIFT, 2012). In this study, 32 per cent of households were found to take loans from family and relatives, and 7 per cent from brokers in the three regions.

Vietnam

Vietnam also has formal and informal rural credit markets, although these differ from Myanmar's. There are three major state financial institutions, namely, the Vietnam Bank for Agriculture and Rural Development (VBARD), the Vietnam Bank for Social Policy (VBSP) and the People's Credit Funds (PCFs). The VBARD was established in 1988 to provide loans for agricultural production, in particular, short-term loans to rural households. It had the largest market share of 84 per cent of total formal credits (27,382 Billion Vietnamese Dong (VND)) to 4 million households (Izumida and Duong, 2001). The interest rate charged by the VBARD is under the management of the State Bank of Vietnam.

The VBARD provides loans at different interest rates based on the size of the loan. For example, monthly interest rate charged by the VBARD is 1 per cent, 0.9 per cent and 0.85 per for loans up to 10 million (VND), up to 50 million VND, and over 50 million VND respectively (Marsh et al., 2006). The VBARD provides loans up to 10 million VND without collateral to households that are engaged in the agriculture sector (Marsh et al., 2006). Family households or commercial farms can borrow up to 20 million VND from the VBARD. However, there is a need for commercial farms or rural households to provide their Land Use Right Certificate (LURCs) as collateral. The State introduced the issuance of LURCs under the Land Law 1987 (Jaffee et al., 2016).

The collateral value of land, which is set by the government, is about 50 to 70 per cent of the land value. The State of Vietnam has given a priority of completion of the issuance of LURCs nation-wide since 2006. Only 30 per cent of farm households have LURCs, therefore, the remaining 70 per cent of rural households are not eligible for the VBARD (Duong and Izumida, 2002). The Ministry of Natural Resources and Environment states that LURCs has been issued to 80 per cent of total agricultural land (World Bank, 2012). On average, a household borrows approximately 2.3 million VND for agriculture, forestry or fishery production, of which 58.7 per cent is mainly received from the VBARD. The period of reimbursement is from 12 to 36 months, and the other type is from 36 months and above due to the loan structure. According to Jaffee et al. (2016), the Ministry of Natural Resources and Environment reports that LURCs have been granted to 80 per cent of agricultural land, 65 per cent of forestry land, and 75 per cent and 65 per cent of residential land in rural and urban areas respectively.

There are no indications that the agricultural credit system of Vietnam is superior to Myanmar's. Although credit is constrained, however, small-scale farm households can access more credit than can large-scale farm households in both countries.

2.8.7 Investment in irrigation infrastructure

Myanmar

Although there has been potential growth in rice production as well as agricultural sector as a whole, this sector has suffered insufficient investment in rural roads, research and development, extension services, and financial support. In contrast, the irrigation infrastructure has been dramatically expanded since 1988, especially in the most rice growing areas. Approximately 66 per cent of MOAI 's budget was allocated to irrigation infrastructure in 2010-2011 through Irrigation Department and Water Resources Utilisation Department (IWUMD) (OECD, 2014). According to MOALI (2018), 95 per cent of capital budget contributes to the main three departments: Department of Rural Development, Irrigation and Water Utilization Management Department, and Agricultural Mechanization Department. The recent revision of budget allocation for 2016-17 and 2017-18 reports that the share of IWUMD has slightly reduced from 33 per cent of the total budget to 26 per cent.

The Irrigation Department of MOALI is the main provider of irrigation services including water distribution, maintenance and operation of facilities for dams and canals. Most irrigated water is for rice production: rice is grown on approximately 75 per cent of land and the remainder is used for pulses, sesame and vegetables (Department of Agricultural Planning, 2013a). The Department charges farmers for irrigation fees at the rate of USD 6 per hectare (1950 Kyat [5] per acre) for dam system and USD 26 for river pumping system (9000 Kyat per acre) (Soe and Kyi, 2016).

Table 2.8 Irrigated area of Myanmar

Year	Net sown area (millin hectare)	Irrigated area (millin hectare)	Percent
1987-1988	7.99	1.00	12.5
1996-1997	9.28	1.56	16.8
1998-1999	9.67	1.69	17.5
2001-2002	10.65	1.99	18.6
2002-2003	10.82	1.87	17.3
2003-2004	11.04	1.96	17.7
2004-2005	11.41	1.93	16.9
2005-2006	11.94	2.14	17.9
2006-2007	12.61	2.24	17.8
2007-2008	13.22	2.22	16.8
2008-2009	13.49	2.28	16.9
2009-2010	13.64	2.33	17.1
2010-2011	13.75	2.29	16.7
2011-2012	13.58	2.11	15.5
2012-2013	13.30	2.12	15.9
2013-2014	13.33	2.17	16.2

Source: MOAI (2013), MOAI (2014)

Over 1988-2014, MOAI constructed 240 dams, 327 river pumping stations and 12,258 ground water irrigation projects (Department of Agricultural Plan-

[5] 1 US Dollar is equalivent to 825 Kyat (Soe and Kyi, 2016).

ning, 2013b). As indicated in Table 2.8, the land under irrigation rose from 1 million hectare (12.6 per cent of total net sown area) in 1988 to 2.17 million hectare (16.2 per cent of total net sown area) in 2013-2014. Despite the increased investment in irrigation projects, the proportion of sufficient water for irrigated areas covered only 17.1 per cent of total net sown areas in 2009, which was relatively low compared to neighbouring countries, such as Bangladesh (57.5%), China (47.3%), India (33.8%), Vietnam (31.9%), Thailand (26.5%) and Lao PDR (22.3%) (OECD, 2014).

Vietnam

During the 1980s, large irrigation projects went ahead in Vietnam, for example, the construction of the Dau Tieng irrigation reservoir supported by the World Bank with the aiming of support an irrigated area of about 172,000 hectares. The irrigated areas accounting for 3.1 and 1 million hectare are mainly concentrated in Mekong and Red River Delta (RRD) respectively. Vietnam's Ministry of Agriculture and Rural Development (MARD) manages its water resources. In 1984, it set up district-level (sub-province). Irrigation Management Enterprises (IMEs) manage government irrigation schemes. At the commune level, water management groups (WMGs) manage irrigation services such as distribution of water to farms and infrastructure maintenance. They charge fees for irrigation services based on paddy output in kilograms, or USD 30 per hectare per annum (Small, 1996).

Vietnam's government has invested heavily in agricultural irrigation: approximately 50 to 55 per cent of the agriculture budget has been spent on irrigation projects. Table 2.9 presents public expenditure for irrigation projects (Barker et al., 2004). The proportion of irrigated area to total rice sown area increased from 46 per cent in 1980 to 85 per cent in 2002 due to increasing variety in cropping intensity (Kubo et al., 2013). To reach the target of 3 million hectare for irrigated water, more than 220 large irrigation projects were completed in 2006. Of Vietnam's total irrigated land, rice is grown on 2.50 million hectare, approximately 63 per cent of the total land area of the country.

Rapid expansion of irrigation facilities has led Vietnam to increase rice production and other crops, such as coffee, pepper and high-valued crops, especially in Mekong Delta. One of the reasons of Vietnam's successful rice production rests on huge amount of investment in irrigation, combined with improved infrastructure, such as better roads and irrigation facilities.

Table 2.9 Public expenditure for irrigation in Vietnam

Year	Current	Capital	Total	Share of irrigation in total agricultural expenditure
	(in 1994 billion VND prices)			(%)
1992	123	551	674	51.2
1993	220	719	939	54
1994	302	1240	1542	77.8
1995	238	1251	1488	65.7
1996	173	962	1135	50.1
1997	107	1142	1249	48.9
1998	101	1435	1536	50.8

Source:Macro Policies and Investment Priorities for Irrigated Agriculture in Vietnam (Barker et al., 2004)

Table 2.10 shows the agriculture public expenditure for irrigation in the ASEAN countries.

Table 2.10 Agriculture public expenditure for irrigation in the ASEABN countries

Country	Agricultural expenditure	Per capita agricultural expenditure	Ratio of agricultural expenditure to agricultural GDP
	(billion 2005 PPP USD)	(2005 PPP USD)	(%)
China	211.3	155.2	24.3
Malaysia	6.3	226.6	17.7
Thailand	6.4	94	9.7
Philippine	3.3	35.1	8
Vietnam	3.3	37.5	6.7
Indonesia	3.9	17.2	3.5
Myanmar	0.4	8.6	1.4

Source: OECD Investment Policy Reviews: Myanmar 2014

In Myanmar, the lesser development of irrigation services is due to the low budget allocation of public expenditure on agriculture. Myanmar has the lowest expenditure on the agriculture sector. The share of agricultural public expenditure to agricultural GDP was 1.4 per cent which was the lowest value among ASEAN countries. In contrast, Vietnam's agricultural public expenditure on agriculture accounted for 6.7 per cent of agricultural GDP (OECD, 2014). Myanmar's under-developed irrigation service might be a consequence of its low public expenditure on agriculture. As a result, Myanmar could not supply enough water to fully utilize existing irrigated areas to grow during the dry season. In addition, approximately 15 to 36 per cent of irrigated areas are used for double-cropping in Myanmar, compared to 50 to 60 per cent of that in Vietnam. This shows that Vietnam is more efficient than Myanmar in providing irrigated water (OECD, 2014).

2.8.8 The cropping intensity in Myanmar and Vietnam

Myanmar

Prior to 1992-1993, rice was only grown in the monsoon season (May to November). Farmers started growing a second crop in summer (December to May) following the introduction of the SPP in 1993. Cropping patterns vary by regional climatic and geographical conditions. Rice-rice or rice-pulse-rice cropping dominates in the irrigated areas. Rice-rice cropping is widely practised in the Delta region, especially in Ayeyarwaddy, the rice bowl of Myanmar. The Department of Agriculture (DOA) reports that Ayeyarwaddy covers 28 per cent of total rice production, which is the most double rice cropping region, followed by Bago and Sagaing at 17 per cent and 12 per cent respectively in 2017-18 (USDA, 2018).

Rice-pulse-rice cropping pattern is mostly found in Yagon, Bago, Mon and Ayeyarwaddy, which are located in Lower Myanmar. Monsoon paddy is grown in many areas such as Bago, Tanintharyi, Mon, Kayin and Rakhine Regions in lower Myanmar, and Sagaing, Mandalay and Magway Regions in Upper Myanmar. These crops are also grown in other regions where irrigated water is available (FAO, 2009). Rice-pulse cropping pattern is mainly practised in the Central Dry Zone, especially in Mandalay, Sagaing and Magway.

In recent years, there has been a decrease in summer paddy cultivation in many parts of the country due to insufficient irrigated water. Many farmers now cultivate pulses and beans in the dry season. Planting these crops following the monsoon rice crop offers numerous benefits to farmers. They need less water, can benefit from the moisture that remains after the harvesting of the rice crop, need less chemical fertilizer than does rice, and their prices are improving.

Vietnam

Up to sixty per cent of Vietnamese farm households grow rice (Yakub et al., 2012). Vietnamese rice production generally involves multiple cropping, increasing the use of chemical fertilizer, smallholders of irrigated farms, and is labour intensive. Cropping intensity varies by region. Ethnic minorities in the Central Highlands and the Northern Uplands generally grow a single crop. Double paddy crops per year such as winter-spring and summer-autumn crops are grown in the north, especially, in the Red River Delta (Minot and Goletti, 2000).

Triple paddy crops such as the winter-spring (around November-February), spring-summer (around March-May) and summer-autumn (around June-September) crops are usually grown in the irrigated areas in the south (Mekong Delta Region)(Hai et al., 2003). This region covers 50 per cent of total rice production and contributes 90 per cent of the annual rice export (VAN et al., 2014). Specifically, the winter-spring crop contributes 46.33 per cent of national rice production, while summer-autumn and autumn-winter crops account for 26.39 per cent and 27.29 per cent respectively. Modern high yielding varieties of rice are mainly planted in the irrigated and rainfed areas (Baulch et al., 2008).

2.8.9 Conclusion

This review has examined the differences in land reforms and agricultural reforms between Myanmar and Vietnam, and their impact on rice production in two countries over time. In Vietnam, land reform has contributed to a dramatic increase in rice production. Although not enough time has passed since the introduction of Myanmar's land reforms in 2012 to asses its effect on rice production, it is expected to deliver similar outcomes.

This review finds that the availability of irrigated water plays an important role in boosting rice production in both countries. Myanmar has a smaller irrigated area suitable for rice compared to that of Vietnam. Due to less available irrigated water, many farmers in Myanmar, especially in the Dry Zone, cultivate pulses instead of rice as a second crop. Vietnam, however, has sufficient irrigated water to permit triple cropping in much of the area in the country. This review also shows that the low rate of the use of chemical fertilizer and poor seed quality might be the main reasons of low yield levels in Myanmar. Insufficient working capital constrains farmers' use of fertilizer, certified or quality seed.

Vietnam is a more efficient rice producer than is Myanmar, due to its better irrigation system, use of better quality seed, higher application rate of fertilizer, and more intensive cropping. Vietnam 's investment in research and development (R & D) is significantly higher than that of Myanmar. In Myanmar, the higher portion of budget allocation is mainly contributed to irrigation department compared with others, such as certified seed distribution, agricultural extension services, and rural road infrastructure. Vietnam's experience shows that Myanmar can increase the quantity and quality of its rice production by applying certified seeds, efficient use of fertilizer, and access to sufficient irrigated water. The government of Myanmar (GOM) should provide sufficient agricultural credit and encourage the private sector to participate in rural credit markets. The GOM should also support the cultivation of summer paddy in the irrigated areas with soil suitable for rice cultivation. An area for future study is the impact of land reform in 2012 on rice production, after sufficient time has passed for the effects to become apparent.

Chapter 3

The impact of credit policy on rice production in Myanmar: A fuzzy regression discontinuity design approach

3.1 Introduction

Agricultural credit plays a crucial role in increasing productivity and developing the agricultural sector in many countries. Access to credit is the key determinant in improving productivity because farmers can purchase better production inputs consisting of fertilizers and seeds, hire more labour and use advanced technology when they have more credits. However, measuring the impact of credit programs is challenging due to a self-selection bias. This challenge is further complicated by the targeting nature of financial institutions' and governments' policies.

Over the last decades, Myanmar has relied on government subsidised credit for household farms as a key financing policy to improve agricultural productivity. In many developing countries, such as Myanmar, agricultural credit is used as a major tool to develop rural areas and reduce poverty. Rice is the most important crop in the agriculture sector, as rice is a staple food crop of the people of Myanmar and a principal export commodity. Being a traditional agricultural economy based on rice production, rice production employs the highest percentage of the total labour force and contributes 75 per cent of rural household income (Wong and Wai, 2013). Rice production contributed 40 per cent of the gross agricultural product and 13 per cent of GDP of Myanmar in

2013-2014 (KPMG, 2015).

Given its important role in national food security, and in social and political stability, the development of the rice production sector is the Government of Myanmar's top priority (Ministry of Agricultural and Irrigation, 2015). The government, therefore, supports the rice production sector with the objective of reducing poverty and developing rural areas. In an attempt to fulfil this objective, the government established the Myanmar Agriculture Development Bank (MADB) and has provided agricultural credit to farmers at subsidized interest rates since 1953. In addition, the MADB is the largest financial institution in Myanmar providing agricultural loans to farmers, especially to low-income farm households. The MADB has supported 1.87 million farmers through 220 bank branches (24 per cent of branches of all banks in Myanmar all over the country) (Win, 2013). The MADB, therefore, plays an important role in the development of the agricultural sector among government organizations, non-government organizations (NGOs) and other financial organizations in Myanmar.

Despite the rapid expansion of agricultural loans by the MADB to improve the rural development of Myanmar, there are some limitations on applying for credit from the MADB. The MADB only provides agricultural loans for major crops including paddy, groundnut, sesame, beans, cotton and corn, and makes only limited number of loans. The MADB bi-annually lends 100,000 Kyat per acre (approximately USD 100 per acre) for paddy[1], and 20,000 Kyat per acre (approximately USD 20 per acre) for the production of groundnut, sesame, beans, cotton and corn, for a maximum of 10 acres at an interest rate of 8.5 per cent per year. Furthermore, the MADB does not finance farmers who are engaged in other agricultural business activities, such as livestock, fishery and forestry activities.

The purpose of loans provided by the MADB is mainly for short-term working capital in production, which is not sufficient to cover the costs of rice production. Farmers, therefore, cannot afford to use better quality seeds and the required amount of fertilizer, and this has a negative effect on rice productivity. In addition, farmers cannot invest in the adoption of new technologies if they are constrained by access to credit (Akudugu et al., 2012). Kubo et al. (2013) demonstrates that Myanmar's annual average yield has been stagnant at 3 tons

[1]The prevalent exchange rate at the time of the survey was 1000 Kyat=1 USD. In terms of land measurement, the amount of credit per hectare is approximately USD 247/ha (Department of Agricultural Planning, 2013a).

per hectare in recent years. Due to insufficient working capital, farmers have to borrow from informal lenders at higher interest rates that lead to increases in production costs and decreases in their income.

Although access to credit contributes to high productivity and the development of the agriculture sector, the impact of credit on farm households is still controversial (Aktaruzzaman, 2013). Akinbode (2013) and Kompas et al. (2012) found that there was a positive impact of credit on agricultural productivity in Nigeria and Vietnam. Additionally, Guirkinger and Boucher (2008) estimated a negative effect of credit constraint on rice productivity in Peru. Conversely, Aktaruzzaman and Farooq (2016) analysed the impact of microcredit on borrowers' expenditure based on the size of land holding in Bangladesh. They applied a fuzzy regression discontinuity design approach (FRD) as the credit allocation did not strictly follow the rules laid down by different microcredit programme. Their findings showed a negative effect of credit on per capita expenditure for durable goods, while there had been no impact on non-durable goods. Overall, their results indicated a positive impact of microcredit on expenditure at the village level.

Previous studies have not analysed the impact of credit policy on rice production using the fuzzy regression design approach. Similarly, little is known about the impact of credit and its constraints on rice production in the case of Myanmar. Previous empirical studies, for example, those conducted by Aung (2011) and Nan Wutyi et al. (2013), have investigated a number of factors that affect rice production. Nan Wutyi et al. (2013) argued that there was a negative effect of access to credit on rice production, especially for large farms. None of them, however, have presented the constraints of credit policy and its impact on rice production in their studies. The objective of this research is, therefore, to fill the gap by analysing the availability of the amount of credit from the MADB to improve rice production of the selected farm households in Myanmar's most productive rice growing regions, specifically, Ayeyarwaddy, Bago and Sagaing. The research question for this paper is, "What is the effect of agricultural credit on rice production and rural income in Myanmar?"

With respect to analysing the impact of the MADB's credit policy, this paper addresses the relationship between availability of agricultural loans and productivity, and how the government of Myanmar can support increased rice paddy production in the selected regions. A fuzzy regression discontinuity (FRD) approach is used to measure the impact of a large-scale long-lasting subsidised credit programme for rice production in Myanmar on a range of possible outcomes including rice output, yield and income, and total income. Identification relies on an arbitrary element in the credit provision rule, which sets a threshold of 10 acres as the maximum for farmers to borrow a fixed amount per acre that limits landholding size for rice production and cultivated land size for other non-rice crops.

Due to the group lending system, the MADB's subsidized credit programme without collateral has higher repayment rates that differ from the experience of most subsidized rural credit programs in other countries. The data used in this paper is taken from author-collected survey data consisting of 634 farms across 30 villages in these regions. Findings suggest the confirmation of the validity of a discontinuity and different specifications in the robustness checks. Although there is little evidence of the credit on rice output and rice income, the MADB's credit programme has the positive effect on total income in the selected regions, suggesting that spillover effect on other farm income activities.

The rest of this research is organized in six sections. Section 3.2 explains the brief history of institutional rural credit in Myanmar and background of the MADB and it's main task of provision for loans. Section 3.3 presents the literature review. The data source and variables are described in Section 3.4. Section 3.5 examines the FRD methodology. In this approach, 10 acres is used for the construction of an instrumental variable. The results of data set are discussed in Section 3.6. Finally, the detailed results of findings and concluding remarks are provided in Section 3.7.

3.2 Brief history of institutional rural credit in Myanmar

Until recently, Myanmar had been isolated from the world for decades due to its inward-looking self-reliant policy in the form of "Burmese Way to Socialism". As a result, it remains an agricultural economy in which the agriculture sector represents between 35 to 40 per cent of gross domestics product (GDP), up to 70 per cent of the labour force and generates between 25 to 30 per cent of total export earnings (De Luna-Martinez and Anantavrasilpa, 2014). Rice dominates the agriculture sector, being the main staple of the national diet, a primary source of income for households and bringing important export revenues for the country. In this context, simulating rice production has been a key priority for the Myanmar government (Ministry of Agricultural and Irrigation, 2015), defining its rural finance policies. This section discusses the history of rural institutional finance since the independence in 1948 until recently.

3.2.1 From the independence to the first reform in 1987

Since the early 1950s, the Government of Myanmar has implemented various programs to develop the country's agricultural sector, including the provision of loans to farmers. The parliamentary government of Myanmar abolished private money lending and lent agricultural loans through the government township officers and cooperative societies until 1953. Despite the emphasis on providing sufficient institutional agricultural credit to support the agricultural sector, the government had met only 12 to 15 per cent of the need for the rural credit (Steinberg, 1981). Since loans, which were provided at 6.5 per cent interest rate per year, were not secured and supervised, the repayment was poor, leading to outstanding farm debt being more than half of farm income (Steinberg, 1981).

In this connection, the government established the State Agricultural Bank (SAB) in 1953 as Myanmar's fundamental institution for rural finance. The SAB was the main financial institution and took responsibility for providing agricultural loans to farmers. Yet for the first five years, credit was channeled to farmers via trained field workers and through cooperatives. Eventually, a network of village agricultural banks was gradually developed. The number of village banks increased from 1290 banks in 1958 to 11,207 banks in 1978, with a presence in almost every village in the country (Steinberg, 1981). Each village bank served one village tract under the management of a selected village committee. From 1953 to 1960, agricultural loans provided by the SAB satisfied just under a quarter of total demand. The SAB charged an interest rate of 6 per cent per annum to the village banks, which redistributed the loans to the farmers at an interest rate of 12 per cent per annum (Win, 1991), while reported repayment rates vary by source, ranging from 70-80 per cent to 92 per cent (Win, 1991; World Bank, 1974). In this way, the village banks played an increasingly important role as the main source of agricultural loans for farmers until 1958. In particular, each village bank served one village tract under the management of a selected village committee.

From 1964 onward, the SAB introduced measures to increase loans repayments. In particular, it reduced the total amount of new loans and provided these only to farmers who had repaid their previous loans (World Bank, 1974). Besides, it imposed a penalty charge of 1 per cent per month above the regular interest rate charge to borrowers with overdue loans. Finally, from 1965 t0 1971, members of village banks were held collectively responsible for repayment of loans. These measures initially improved loan repayments, up to 96 per cent in 1969, but the deteriorated again in the early 1970s (World Bank, 1974, p.36). During this period, the SAB charged an interest rate of 9 per cent, of which village banks kept 6 per cent for thier operation and bore the burden of unpaid debts. In 1970, the SAB merged (as the Agricultural Finance Division) with the People's Bank, to form the Union of Burma Bank (UBB), the only bank in Myanmar under a mono-bank system.The provision of loans through cooperatives had ceased since 1958. The village banks, however, continued to provide banking services.

Although the high repayment rates in the late 1960s were commendable given that the loans were unsecured, there were some issues with government credit provision. First, loans that became delinquent were usually not followed up and repaid in later years, which resulted in a growing number of farmers ineligible to receive new loans (World Bank, 1974). Second, a severe shortage of institutional credit led to a predominant role of illegal private credit. With interest rates ranging from 40 to 400 percent per year, private credit was estimated to be three times as much as institutional credit (Steinberg, 1981). Finally, farmers used up to 35 percent of crop production credit for their subsistence expenses before harvest, a further amount spent on hired labour, and only a small share of credit spared for seeds, fertilizers and other productive inputs (World Bank, 1974).

Between 1973 and 1977, the leading operations of village banks reduced substantially due to the implementation of an advance purchase system by the cooperative societies. Under this system, farmers could receive an advance of up to 70 per cent of the government procurement quotas in cash or in kind (Steinberg, 1981). In June 1974, the government introduced another advance purchase scheme only in rice surplus areas in Lower Myanmar, while the Union Bank through village banks supplied it in other areas (Steinberg, 1981). In these rice surplus areas, farmers could get a further advance from the government, contingent upon their landholding area, but were required to sell their corresponding products to the state at the state price. Although the official interest was zero under this system, the effective interest could be substantial due to the wedge between the state price and the market price, resulting in farmer's reluctance to participate. Private lending, though illegal, was estimated to account for about 40 per cent of total rural credit provided at interest rates of up to 10 per cent per month (Steinberg, 1981).

In 1976, the Agricultural Finance Division was separated from the UBB to become the Myanmar Agricultural Bank (MAB). The separation followed the 1975 Bank Law, under which the mono-bank system was dismantled; the UBB became the Central Bank, and three specialised banks emerged under its supervision. In addition to the MAB, these include the Myanmar Economic Bank (MEB) and the Myanmar Foreign Trade Bank (MFTB). The MAB was in charge of providing seasonal, medium-term and long-term agricultural loans.

From 1978 to the early 1980s, the MAB had increased its disbursement substantially to support the launch of the Whole Township Rice Production Program (WTRPP) in 1978. Considerably increased the availability of agricultural loans, especially after the introduction of the WTRPP in 1978 (Win, 1991). This WTRPP introduced modern high yielding varieties (HYV) of rice to enhance production possibilities. As a result, the MAB's lending increased due to both the expansion of area devoted to HYV and the rise in lending rates to satisfy a much higher need for fertilizer of HYV to generate high yields.

Farmers received loans via village banks at the interest rate of 12 per cent and were required to save 1 per cent of the loan. Village banks enjoyed a margin of 4 per cent interest rate, a 10 per cent commission on the loan principal recovered plus 2 per cent of all interest recovered (Win, 1991). These incentives, as well as increased supervision, contributed to smooth disbursement and recovery rates over 90 per cent for seasonal loans. At the same time, the MAB's lending portfolio skewed heavily in favour of rice production, covering 85 to 88 per cent of all crop loans and approximately 80 per cent of the credit requirement for rice (Win, 1991).

But as the economy deteriorated in the mid-1980s, farmers again faced severe credit constraints. With inflation around 20 to 30 per cent per annum, money printing to finance budget deficits, the demonetisation of currency notes in 1985 and 1987 and the removal of subsidies on agricultural inputs such as fertilizer in 1987, agricultural inputs became less affordable for farmers. As a result, fertilizer usage dropped to levels as low as before the launch of the

WTRPP, reducing the effectiveness of the WTRPP in expanding the use of HYV.

3.2.2 From the first reform in 1987-1988 to present

A market-oriented policy was adopted in 1988, followed by the promulgation of new bank laws to open the financial sector to private and foreign investors. This policy change also saw a restructuring of the MAB. The MAB was reorganised as the Myanmar Agricultural Rural Development Bank (MARDB) in 1990 under the Central Bank of Myanmar Law. The MARDB was transferred to the Ministry of Agriculture and Irrigation (MOAI) from the Ministry of Finance and Revenue. With the aim of supporting the development of the agricultural sector, livestock and rural socio-economic enterprises by providing banking services, the MARDB was reconstituted as the Myanmar Agricultural Development Bank (MADB) in 1997 (Thein, 2004). However, the reforms in the financial sector that were initially planned in 1988 were implemented only partially due to the Asian financial crisis in 1997 and the banking crisis in early 2003.

The nation-wide network of about 11,200 village banks was replaced with a system of branch banks between 1998 and 2000 (Fujita et al., 2009). Despite the fact that the MADB mainly relied on the village banking system, the government replaced village banks with the branch banks system and introduced the branches of farmers' groups in 1998. Under this framework, only the branch bank in each township is entitled to offer savings deposits and loans to farmers. This branch network has 220 banks as of 2013, accounting for 23 per cent of all bank branches in Myanmar (De Luna-Martinez and Anantavrasilpa, 2014).

The MADB is mainly provided with subsidized funding by the government through the state-owned Myanmar Economic Bank (MEB). More specifically, the MADB currently borrows funds from the MEB at a 4 per cent per annum subsidized interest rate. Due to support from the MEB, the MADB can redistribute those loans to farmers with an interest rate of 8.5 per cent per annum (De Luna-Martinez and Anantavrasilpa, 2014). The MADB can finance in kind or in cash or both to farmers in accordance with the law, however, the MADB can only provide loans in cash to farmers. In addition, the MADB can only provide loans for a limited range of crops such as rice, cotton, sesame, beans, groundnut and corn.

Since 2011, the MADB's subsidised credit policy has been increasingly out-of-date in the context of vigorous economic reforms. In particular, as the economy is growing faster, the consumer price index (CPI) is getting higher. This situation makes the interest margin enjoyed by the MADB shrink when it maintains a fixed interest policy of 8.5 per cent per annum. By 2013, the MADB has become dependent on government subsidies, causing a fiscal burden of about 0.2 per cent of GDP (De Luna-Martinez and Anantavrasilpa, 2014). This dependency and fiscal burden has forced the MADB to narrow its lending portfolio to a limited number of crops, despite its mission of providing banking services to support the development of agriculture, livestock, and rural socio-economic enterprises.

Currently the MADB offers three types of loans, namely seasonal crop production loans (SCPL), term loans (TL) and area development loans. However, its lending activity is dominated by SCPL which in 2012 accounted for 98 per cent of the total loans (De Luna-Martinez and Anantavrasilpa, 2014). SCPL loans have been provided to the production of eight main crops, namely paddy, which becomes rice after the removal of husk by threshing, groundnut, pulses, sesame, cotton, jute, maize and mustard since 1998 (Win, 2013). Seasonal loans dramatically increased from 122 billion Kyat in 2000-2001 to 570 billion Kyat in 2012-2013. In addition, the MADB has served approximately 1.6 million clients with seasonal loans, with a total land area of 1.4 million acres in 2012-2013 (Duflos et al., 2013). Meanwhile, the marginalised TL loans are to finance sugarcane plantation, tea processing and solar salt production. The MADB finances long term loans for oil palm plantations and palm oil refineries, green tea plantations and coffee plantations. According to the MADB's annual report in 2012, the MADB had total assets of 116 billion Kyat (USD 132.6 millions), total deposits of 86.9 billion Kyat (USD 104.3 million) and total loans of 84 billion Kyat (USD 96 million).

As the demand for MADB loans is higher than the supply given the interest subsidy, the MADB has also rationed the loans in addition to focusing only on key crops. In particular, for each season, it lends 100,000 Kyat (approximately USD 100) per acre for paddy production and 20,000 Kyat (approximately USD 20) per acre for other crops. And the maximum loan size is based on the agricultural landholding area which the farmer has a land titling right, and capped at 10 acres per farm household.

To maintain high repayment rates while not requiring any collateral from farmers, the MADB has some other lending rules. First, farmers-borrowers need to have their loan applications approved by a loan screening committee set up in each village. The committee comprises of the head of village and representatives from the Land Record Department, the Department of Agriculture, the Industrial Crop Department, and the farmers, thereby reducing information asymmetry problems (De Luna-Martinez and Anantavrasilpa, 2014). Second, farmers-borrowers are required to form lending groups of 5 to 10 members, accepting liability for both their individual and other group members' loans (Fujita et al., 2009; World Bank, 1974). There are 300,000 farmer groups across the country. The MADB only provides loans to farmers in townships with full repayment history.

Finally, in addition to having a good credit history, farmers need land titling rights to be eligible for MADB loans. These rights were required for annual registration and renewal until 2012. Farmer Registration Books are issued by the village authorities and are used to verify farmers' land tilling rights (De Luna-Martinez and Anantavrasilpa, 2014). Under the framework of land tilling rights, farmers cannot use land tilling rights as loan collateral, because those rights are strictly prohibited from sales, the mortgage of land and lease or transfer. However, the government enacted the Farmland Law and the Vacant, Fallow and Virgin Land Management Law (VFV Law) to fulfil the objective of securing access to land for rural development in 2012. Under the Farmland Law 2012, farmers have more freedom to sell, transfer, mortgage or rent their land use rights to others and the duration of the right for farming is unlimited as long as certain conditions are met.

To this end, the MADB has maintained high repayment rates unlike its counterparts in many developing countries. Its non-performing loans represented only 0.02 per cent of the total lending in 2012-2013 (Win, 2013). Furthermore, group lending was implemented as early as in 1965-1966, well ahead of the global renovation in microfinance in the 1990s, and has been fully implemented since 1998. However, the downside of this achievement is that more than 3.5 million farmers, most of whom are poor, are not served by the MADB due to the widespread lack of land titles (De Luna-Martinez and Anantavrasilpa, 2014).

The dominant role of MADB started to reduce since the adoption of the Microfinance Law in 2011 which opened the rural credit sector to other stakeholders. Based on limited data, an estimate by Duflos et al. (2013) suggests that the outstanding loans of MADB represented only 36 per cent of the total outstanding loans by all microfinance providers in 2011-2012, but its clients accounted for more than half of total clients served by these institutions. The latter is due to the MADB having the largest bank network covering the whole country.

Although the MADB becomes the main provider of agricultural loans, there are some other institutions that also finance loans to farmers. Generally, the rural credit markets in the Myanmar agricultural sector can be categorized into three sectors, namely the formal, semiformal and informal sectors. Formal financial institutions include the MADB, public pawnshops and legal private pawnshops, and savings and credit cooperatives. Semi-formal credit markets consist of local and international non-government organizations and microfinance institutions (NGO-MFIs), and the welfare programme of the Human Development Initiative by UNDP. Among these organizations, the United Nations Development Program's (UNDP) Partner Agencies Collaborating Together (PACT UNDP) program provides agricultural loans at an interest rate of 2.5 per cent per month, especially in the Dry Zone. Likewise, the international NGO World Vision also provides loans at an interest rate of 2.5 per cent per month in the Ayeyarwaddy Region (Duflos et al., 2013). Lastly, the informal sector is composed of illegal pawnshops, traders, money lenders, friends and relatives (Kaino et al., 2005).

Among these financial institutions, including the formal and informal sectors in Myanmar, the MADB still plays an important role in supporting the agricultural sector with the provision of significant loans accounting for 570 billion Kyat (USD 5700 million) in 2012-2013 (Win, 2013). Indeed, loans for paddy production account for 88 per cent of the MADB's loan portfolio. The purpose of loans given by the MADB is to cover the cost of working capital such as for the purchase of fertilizers, seeds, pesticides, and labour wages. The MADB gradually increased its agricultural loans on a per acre basis, from 400 Kyat (approximately USD 4) in 1994-1996 to 10,000 Kyat (approximately USD 10), especially for rice production in 2009-2010. In addition, the MADB has significantly increased the credit per acre to 100,000 Kyat (approximately USD 100) for rice production in 2013-2014. The MADB has further increased the credit per acre to 150,000 Kyat in 2016 (Htoo, 2016).

If farmers are eligible to apply for a loan, they can borrow 100,000 Kyat (approximately USD 100) per acre for a maximum of 10 acres from the MADB at an 8.5 per cent interest rate per year[2]. The MADB disburses loans for monsoon paddy from May to August and collects loan payments between December and March in the following year. Likewise, the MADB gives out summer loans to farmers from September to January and collects loan payments between February and June in the following year. The main crops cultivated in Myanmar are paddy, cereals, pulses, industrial crops (cotton, rubber, jute, oil-palm and coffee), other crops (such as chilli, garlic, onion, ginger, potato, and turmeric), and tropical fruits and vegetables. As previously mentioned, the MADB provides loans for limited crops due to the bank's insufficient capital. There is also a requirement for the MADB to contribute 75 per cent of its commercial profits to the government, which reduces the funds that the MADB can loan out. Consequently, the MADB is not able to provide loans for aquaculture, livestock, fruits and vegetables, and any other agricultural products with high value, and cannot support medium and large farms or other agricultural business (De Luna-Martinez and Anantavrasilpa, 2014, p.16).

Despite the fact that the aim of the programme is to finance rice production costs, the availability of loans is very limited in rural areas. In particular, the estimated cost of rice production is around 200,000 Kyat (USD 200) per acre for low-quality rice and 400,000 Kyat (USD 400) per acre for high-quality rice (De Luna-Martinez and Anantavrasilpa, 2014). Therefore, a loan from the MADB covers only 25 per cent to 50 per cent of the production cost per acre (Haggblade et al., 2013). Consistent with this finding, the production costs including seeds, fertilizers, pesticides, labour and hiring capital in this research was 150,000 Kyat (USD 150) per acre on average. The maximum production cost per acre was around 400,000 Kyat (USD 400) in this study. To meet the remaining amount of the production cost, farmers might borrow from friends, relatives and other informal money lenders with interest rates of up to 10 to 20 per cent per month, which is much higher compared to that charged by the MADB (LIFT, 2012).

The credit programme of the MADB restricts the availability of loans to a maximum of 10 acres; therefore, small farm holders might be beneficiaries of

[2]The interest rate was dropped to 5 per cent in 2014 (Thomas et al., 2015).

this credit program. Under this framework, farms with holdings of more than 10 acres can only receive 1,000,000 Kyat (approximately USD 1000) for their first 10 acres showing that the credit per acre is relatively low compared to those farmers who have up to 10 acres of land. There has been no empirical study that reviews the relationship between access to amount of credit and rice production on the basis of farm land size in Myanmar.

3.3 Literature review

Much of the empirical literature has investigated the access to credit as a powerful tool to improve the well-being of the poor, increase expenditure and savings at the household level, reduce poverty and develop an agricultural sector in most developing countries all over the world. A number of studies have used different methodological approaches in an attempt to analyse the impact of credit on specific areas of interest. The effect of credit, however, is still controversial. Some studies have found that there has been a positive effect of access to credit on households and an increase in productivity in the agriculture sector. Other empirical studies argue that there is a negative impact of access to credit on households' welfare as well as on agricultural productivity.

Karlan and Zinman (2009), for example, showed that an increase in credit supply would help improve a household's welfare. They used a household survey to investigate the behaviour and outcomes of participants in a treatment group and a control group from six months to nearly two-and-half years by applying a field experiment in South Africa. Their estimates showed significant and positive effects of the expansion of credit on economic self-sufficiency, household well-being and food consumption. Similarly, Banerjee et al. (2013) examined the impact of microfinance on consumption, the creation of new business and household income, and showed the positive impacts of microfinance on households in India.

Aktaruzzaman (2013) examined the effect of microcredit programs on the expenditure and savings of participants in Bangladesh between 2006-2007. Under these credit programs, a household that owns at most 50 decimals[3] is eligible to participate in the program. Due to the lack of strict rules in the allocation of credit in Bangladesh, the FRD was applied to examine the credit

[3] Agricultural land is measured in decimals in Bangladesh (50 decimals=0.5 acre).

effect. An instrument variable in this research was the dummy variable and it took 1 if the household owned 50 decimals of land and below, and took 0 if it was otherwise. His findings suggested that access to credit could increase household saving, the expenditure per school child, and help someone to start a new business or to expand in the existing business and to reduce spending for other durable goods. He also showed that the expenditure per school child increased by 23 per cent if there was an increase in 10 per cent of the average amount of credit.

A study by Meng (2013) evaluated the impact of China's poverty alleviation programme, namely the 8–7 plan on the income growth of households in rural areas. The purpose of this programme was to develop the local economy through financing subsidized credits during the period 1994 to 2000. In an attempt to estimate the effect of the programme, the status of initial eligibility for the program was used as an instrument variable in the FRD design approach. His results strongly showed that rural households would increase their income level by 38 per cent if they were included in the treated group between 1994 and 2000. Accordingly, this finding confirmed that access to credit played a crucial role in China's economic development.

Similarly, Ponce and Bedi (2010) also used the FRD to evaluate the impact of conditional cash transfer programs (CCT) on students' cognitive achievement in Ecuador. They identified the Selben index score for the selection of eligibility of households in this program. Under this program, the eligible household would receive a cash transfer of USD 15 per month. Despite the fact that this study used different specification models and sample sizes to identify the effect of the credit program, there was no evidence of the impact of credit on students' test scores. Their result was consistent with Behrman et al. (2000), who also showed that there was no impact of the cash transfer programs on students' test scores in Mexico. Adebayo and Adeola (2008) investigated how the availability of credit in Nigeria could improve living standards in rural areas by increasing productivity leading to more income for farmers. In addition, Akinbode (2013) demonstrated a positive effect of availability of credit from microfinance banks and cooperative societies on rice production in Nigeria.

The expansion of microcredit could help increase the productivity and efficiency of the agricultural sector, especially in many developing countries. The availability of credit can generate a higher yield of production as farmers can use better inputs consisting of fertilizer, seed and pesticide. Kompas et al.

(2012) showed that more credit improved the efficiency of Vietnamese rice production. In their research, stochastic frontier analysis (SFA) was applied to the estimation of credit on rice production using the Vietnam Household Living Standard Survey (VHLSS) data. Their finding was consistent with Duong and Izumida (2002), who found a positive and significant influence of credit on household production.

Duy (2012) used the VHLSS 2008 data to investigate the contribution of credit to rice production efficiency in Vietnam. His study focused on access to credit including formal and informal sources, and consistently revealed a positive effect of credit on rice production as shown in Kompas et al. (2012)'s work. In the case of Nigeria, Akinbode (2013) used the logit regression model and estimated the relationship between access to credit and rice production. Consistent with the previous literature, his study showed that farmers could increase their production efficiently if they had more credit.

However, there has been limited evidence available regarding access to credit and its impact on rice production efficiency in the case of Myanmar. Nan Wutyi et al. (2013) applied stochastic frontier analysis (SFA) to estimating rain-fed rice production efficiency in Myanmar. Contrary to Kompas et al. (2012) and Duong and Izumida (2002), Nan Wutyi et al. (2013) showed a negative effect of credit on rice production efficiency in the selected main rice growing state, specifically in Lower Myanmar.

Other empirical research, for example, conducted by Aung (2011), also investigated the determinants of rice production efficiency in the selected two regions, in particular, Yangon and Bago in Lower Myanmar. Aung (2011), however, did not focus on credit and its effect on rice production. On the other hand, Kaino et al. (2005) examined rural credit markets in Myanmar determining the factors for credit demand, loans from the MADB (the formal sector) and loans from the UNDP's PACT, especially in the Dry Zone.

Kaino et al. (2005) investigated the relationship between the formal institution (MADB) and the semiformal institution (PACT) in selected regions. However, the MADB mainly supports agricultural activities, while PACT pays attention to poor people who are undertaking various business activities. Kaino et al. (2005) showed that the average PACT loan size is larger than that of loans from the MADB, and the promoting of PACT loans might be strengthened as well as the development of the formal credit sector. His study, however, did not focus on the key characteristic of availability of credit from the MADB that is tightly connected with the land size of farm households. His findings also confirmed that the MADB and PACT were the major financial institutions for the provision of credit in the Dry Zone. He argued that both the formal and semi–formal financial institutions could reach the targets of the various segments of credit markets in rural areas in Myanmar. Since there has been no empirical research that pays attention to the impact of credit policy on rice production, this study investigates the effect of the credit policy of the MADB on rice production in the selected areas in Myanmar.

3.4 Data source and variables

3.4.1 Source of data

In this paper, primary field survey data across 30 villages in 2014 is used to analyse the impact of credit policy on rice production in Myanmar. The number of households in this survey totalled 634 farms across 30 villages in 6 townships. In particular, the number of farm households is made up of 215 farms in Ayeyarwaddy, 212 farms in Bago and 207 farms in Sagaing. The sampling framework is shown in Appendix 1.

3.4.2 Rural credit markets

Table 3.1 provides the detailed information on crop credit received by farmers in the selected regions. On average, the outstanding loans in sample farms run for about six months, which suggests that these are likely seasonal crop production loans. Loans for rice production dominate in all regions, and especially in Ayeyarwady where they account for 100 per cent of all crop credit. The MADB plays a dominant role in loan supply, providing 81 per cent of loans in Sagaing, 58 per cent in Bago and 64 per cent in Ayeyarwady, mostly for rice production. Farmers reported having to satisfy all MADB loan requirements: having land-use-right certificates, having a savings account at MADB, and being part of a lending group in addition to being approved by a village loan screening committee. They were charged an interest rate of 0.71 per cent per month (or 8.5 per cent per annum) and could borrow for up to 10 acres only.

Table 3.1 Rural credit markets

Region	Item	Non Rice Crops					Rice				
		Relatives	Brokers	MADB	NGO	Others	Relatives	Brokers	MADB	NGO	Others
Sagaing	Interest	2.50		0.71			4.27	0.83	0.71	1.50	1.48
	(%/month)	(3.54)		(0.00)			(3.03)	(2.04)	(0.00)		(1.34)
	Amount	550		198			527	417	586	100	241
	(000 Kyat)	(212)		(369)			(424)	(306)	(276)		(406)
	Duration	6.00		6.36			6.20	5.83	6.39	6.00	5.29
	(months)	(1.41)		(0.49)			(1.26)	(1.17)	(0.53)		(1.95)
	Observations	2		28			15	6	164	1	21
Bago	Interest	5.38	6.00	0.71		4.88	5.19	5.45	0.71	2.82	2.33
	(%/month)	(2.20)	(0.00)	(0.00)		(1.65)	(2.14)	(4.03)	(0.00)	(1.06)	(1.88)
	Amount	794	925	194		1475	1055	1150	967	447	652
	(000 Kyat)	(649)	(435)	(175)		(1284)	(1036)	(859)	(594)	(1020)	(1062)
	Duration	6.12	7.00	6.12		6.75	6.29	7.18	6.37	5.82	5.83
	(months)	(1.55)	(0.00)	(0.56)		(2.50)	(1.78)	(2.89)	(0.52)	(0.60)	(1.81)
	Observations	8	4	40		4	91	22	220	11	48
Ayeyarwady	Interest						7.75	5.91	0.71	1.85	4.81
	(%/month)						(14.03)	(1.70)	(0.00)	(1.10)	(14.41)
	Amount						639	1068	724	253	1110
	(000 Kyat)						(714)	(907)	(327)	(104)	(1333)
	Duration						5.56	7.91	5.99	5.31	4.45
	(months)						(1.24)	(2.55)	(0.77)	(0.73)	(2.90)
	Observations						94	11	345	39	47

Notes: Standard errors are in parentheses.

The second primary source of credit is from relatives followed by NGOs and other financial institutions, such as PACT and co-operatives. Loans from relatives comprise 7 per cent of all loans in Sagaing, 22 per cent in Bago and 18 per cent in Ayeyarwaddy. The monthly interest rates of this source are 4 per cent in Sagaing, 5 per cent in Bago and nearly 8 per cent in Ayeyarwaddy, which are higher than that of the MADB. The other financial institutions, such as PACT, NGOs and co-operatives provide loans at an interest rate of 2.5 per cent per month. However, NGOs and other credit institutions such as pawnshops play a negligible role in credit supply for crop cultivation in the three study regions. [4]

3.4.3 Description of variables and descriptive statistics

In an attempt to analyse the credit policy, the main variables used in this paper are rice output, landholding size [5] and the availability of credit from the MADB for each farm household. Rice output (OUTPUT) is the total output of rice in kilograms, produced by each farm. Landholding size (LAND) is the total holding size of each household (measured in acres), as well as the total planted land (both owned and rented, measured in acres) used in annual paddy production. CREDIT is the total credit (in thousands of Kyat) that farms borrow from the MADB for summer paddy and monsoon paddy. Total income is based on revenues from rice, other crops, livestock, fishery, horticulture and non-farm household business activities per year. The key exploratory variable of interest is total MADB credit for summer paddy and monsoon paddy.

In addition to these key variables, this study uses a number of independent variables as controls in the regression analysis, as they may affect rice production. The demographic characteristics of a household head are captured by the number of household members who are currently involved in the business activities, and the dependency ratio (the number of non-working family members over the family size). The number of working family members determines both farm production and other sources of income. The number of dependants in a household is also required to consider its effect on rice production. Indeed,

[4]The survey data shows a slightly different picture of the credit market compared to LIFT (2012) regarding the source of credit and interest rates. In particular, LIFT (2012) find that the key source of credit for households is families, friends and brokers and the interest rates are 10-20 per cent per month. This difference comes from different samples, with LIFT (2012) covering all households who live in a broader geographical area, while our sample includes only rice farm households from three regions.

[5]Landholding size is defined as total area of land owned by each household. The cultivated land is defined as the actual land acre for cultivation of rice.

households with higher number of dependants might produce lower levels of rice yield compared to those households that have fewer number of dependants.

Proxies for the skill level of farmers are age and education level of the household head. Education is categorised by three different levels: at most primary school, secondary school, and high school or higher education. The gender of household head is also included. GENDER is defined as the dummy variable if the household head is male (=1) or otherwise (=2). The respondent farmers were asked to self-assess the water availability from irrigation or natural resources, such as creeks, rivers, dams and reservoirs, and private channels (identified as 1= very good/good, 0 if it is otherwise). Availability of agricultural extension services is defined as a farm household receiving services from different institutions for farming activities.

The distance from a village to a township is considered to be an important factor in applying for agricultural credit. Transportation costs might be more expensive if a village is located far from a township compared to a village that is closer to a township. Due to a lack of good roads and transportation, travel time and transportation costs can pose substantial obstacles to credit and diminish production efficiency (Tracey-White, 2005). According to Li et al. (2011), households that are located closer to a township's bank branch are more likely to apply for loans compared to those households that are located very far from a township's branch. Sibiko et al. (2013) and DeSilva (2011) have demonstrated the negative effect of distance to market and suggested that the development of roads and infrastructure in rural areas might improve the efficiency of farms in Uganda and the Philippines respectively.

The distance measured in kilometres is a proxy for the travelling distance of the client farmers from each village to a township's bank branch of the MADB to receive their loans. In this study, it is found that households located greater than 96 km from a township's branch bank do not apply for agricultural loans. In order to capture the regional effects on rice production, the binary variable is identified as 1 if farm households are located in the Delta Region; it is 0 otherwise. Ayeyarwaddy and Bago are located in the Delta region, which has better conditions, such as higher annual rainfall and more fertile soils, for agriculture compared to conditions in the Dry Zone. Previous literature (for example, Kompas et al. (2012)) analysed the effects of region on rice production in Vietnam and showed the benefits of the major rice producing region.

Table 3.2 Summary statistics for the selected farm households

Variable	Units	Mean	Std.Dev	Min	Max
Output(kg) (Y)	kg	15831.26	16902.82	209	129580
Output per acre (kg)	kg	1087.52	420.48	31.35	2382.60
Landholding size (LAND)	acre	11.64	11.31	1.37	70
Total cultivated area (owned or rented)	acre	13.71	12.96	1	84
Household head					
Age of household head (AGE)	years	51.09	11.87	22	86
Gender (GENDER)	male=1	1.04	0.21	1	2
At most primary education (EDU12)	yes=1	0.62	0.49	0	1
Secondary education (EDU3)	yes=1	0.25	0.44	0	1
High school/ higher education (EDU45)	yes=1	0.13	0.34	0	1
Farming experience (EXP)	years	27.91	12.65	2	65
Number of household labour (HHLAB)	number	2.91	1.52	1	10
Dependency ratio (DEP)	ratio	0.45	0.23	0	0.90
Irrigation services good/very good (IRRI)	yes=1	0.82	0.38	0	1
Agricultural extension services (AES)	yes=1	0.58	0.49	0	1
Region (REGION)	Delta=1	0.67	0.47	0	1
Distance to township's bank branch (DIST)	km	17.02	19.65	1.61	96.60
Rice income	000 Kyat	3299.41	3638.79	50	24750
Rice income per acre	000 Kyat	224.35	103.29	9	680
Total income	000 Kyat	4304.83	4223.84	120	38190
Credit per acre from MADB (CREDIT)	000 Kyat	96.00	55.69	0	285.71
Total farm households (N)	number	634			

Table 3.2 shows a summary of descriptive statistics for the selected farm households used in this study. The average landholding size is 11.64 acres and rice output is about 15,800 kg. The average cultivated area is 13.71 acre, and average amount of credit from the MADB is 96,000 kyat per acre. The summary of farms with land holdings of up to 10 acres and larger than 10 acres are presented in Tables A1 and A2. Farms with land holding up to 10 acres produce only 25 per cent of rice output that large farms produce (see Table A2).

3.5 Methodology

3.5.1 Regression discontinuity

Thistlethwaite and Campbell (1960) firstly introduced regression discontinuity design (RDD) to evaluate social programs. Since the late 1990s, this approach has been widely used for the evaluation of social assistance programs in Canada (Lemieux and Milligan, 2008), the impact of the Reading First Program on instructional practice and student achievement in the United States (Gamse et al., 2008), and the effects of financial aid offers on college enrolment (Van der Klaauw, 2002). This design is characterized by the treatment assignment, which is based on whether an observed variable occurs above or below the arbitrary cut-off point (Lee and Lemieux, 2009). The main assumption of this design is that people who are below the cut-off point or who do not receive the treatment can be compared to those people who are above the cut-off point or who receive the treatment.

In addition, the difference between treated people and controlled (non-treated) people is not great if people are very close to this cut-off point. In order to test the validity of RD designs, the baseline (or predetermined) covariates can be used to identify the randomization result. If there is a variation in the treatment variable that is closely randomized around the cut-off point, all those baseline characteristics below and above the cut-off point might have no difference in outcomes. Alternatively, RD design can be shown with a simple graph to visualize a relationship between the outcome variable and assignment variable. This graphical presentation can clearly provide the evidence of a discontinuity at the cut-off point. In addition, the RD design approach is appropriate if the assignment variable is continuously related to all other unobserved factors. Theoretically, there are two types of regression discontinuity design, namely sharp regression discontinuity design (SRD) and fuzzy regression discontinuity design (FRD). The formal design can be applied when treatment status and the cut-off point have a deterministic relationship. However, the relationship is not likely to be perfect in practice as the treatment variable may not be strictly determined by the cut-off point in the fuzzy design (Lee, 2008).

In the case of the fuzzy design, the treated and control groups are on both sides of the cut-off point that consists of people who are assigned to the control group with treatment and without treatment. Under the MADB framework, the farms with holdings larger than 10 acres of land cannot receive loans based on their large land size. In contrast, farmers with holdings of up to 10 acres of land size can receive loans in accordance with their land size. Accordingly, there is an imperfect relationship between the assignment variable (land size) and the status of receiving certain amounts of loans. Under the assumption made by Hahn et al. (2001), the 'monotonicity' that refers to L_i (land size of each farm household) crossing the cut-off point ($L_i \leq 10$) does not allow some units to receive the treatment while others are rejected from the treatment at the same time. In addition, there might be other unobservable factors that are probably correlated with the outcome, suggesting endogeneity bias in treatment status.

Theoretically, the two approaches, namely the local linear regression and polynomial regression, can be used for estimating the fuzzy RD design. Analytically, two-stage least squares (2SLS) can be used to estimate the effect of treatment in this design (Hahn et al., 2001). Following Lee and Lemieux (2010), the model of 2SLS is carried out as follows:

$$First\ stage\ equation : T_i = \alpha_0 + \gamma_0 D_i + \gamma_i f(L_i) + \gamma_i X_i + \epsilon_i \tag{3.1}$$

$$Second\ stage\ equation : Y_i = \delta_0 + \beta_0 \hat{T}_i + \beta_i f(L_i) + \beta_i X_i + \mu_i \tag{3.2}$$

Where Y_i is the outcome variable for individual i, T_i is defined as 1 if individual i receives the treatment or the MADB credit per acre, and 0 if an individual i does not receive the treatment, D_i is 1 if individual i is assigned to treatment based on the cut-off rule, and it is 0 otherwise, X_i is an assignment variable for an individual i, ϵ_i is a random error term for individual i, μ_i is random error that is assumed to be identically and independently distributed, and β_0 is the marginal impact of the programme at the cut-off point. Ordinary Least Squares (OLS) regression is used to estimate the first stage equation and predict the value of $\hat{T}_i$. This predicted value $\hat{T}_i$ is used in place of T_i in the second stage of the equation, and then the parameter of β_0 can be estimated by using OLS regression.

3.5.2 Econometric model specification

As previously mentioned, the MADB is the main financial institution that provide loans for farm households with the aim of developing rural areas. The objective of this study is to identify the casual effect of the MADB credit scheme on a range of various rice-related outcomes such as rice output, yield, and income, as well as the total income for farm households. The primary threat of endogeneity comes from potentially confounding characteristics that affect both rice production and the amount of credit received. First, the targeting design favours relatively more capable farmers that tend to have good credit histories. Second, the scheme involves an element of self-selection by which risk adverse, lower educated, or less motivated or confident farmers are less likely to take up credit. Both these effects can lead to a positive bias, and hence an overestimate, of the effects of providing MADB credit on rice yields and income.

Although considerable factors have been focused on the level of rice production efficiency in Myanmar, there has been limited attention paid to the credit policy of the MADB and its constraints on rice production. Under the agricultural credit policy, the MADB provides loans for a maximum of 10 acres of land size. To address this problem, our identification strategy exploits the targeting design of the MADB program. This program introduces a discontinuity in eligibility around a threshold of 10-acre of rice land area with right use certificates. Farms just below and just above this threshold are not equally eligible for a loan. Obviously, small and large farms are not a proper comparison, as land size is a key factor for production and income. Yet, there is no reason to expect that farms close enough to the threshold on both sides are different in any characteristics other than the MADB eligibility.

Note that this threshold is not a clear cut off being eligible to borrow 100,000 Kyat (USD 100) per acre per cropping season, and the maximum amount that can be borrowed increase linearly with the land size. For farms larger than 10 acres of total amount is capped at 1,000,000 Kyat (USD 1000) per season for their first 10 acres, which means the average credit per acre decreases as land size increases above 10 acres. This set up, therefore, implies a fuzzy regression discontinuity design (FRD): farms on either side of the threshold receive credit, but at the threshold, there is a discontinuity in the eligible amount of credit per acre.

To estimate the effect of treatment variable or the MADB credit per acre, the instrumental variable (IV) approach as suggested by Hahn et al. (2001) is used in this study. The size of the household's land is identified as an instrumental variable to evaluate the influence of credit policy on farmers, in particular, who have holdings of 10 acres of land size. Since the 10-acre threshold is an arbitrary decision, we expect that conditional on actual land size, D does not have an effect on the outcome variable other than through the MADB scheme, satisfying the exclusion restriction. If the exclusion restriction holds, then we can interpret β as the casual effect of providing credit of 1,000 Kyat per acre where β is the ration of the reduced-form effects of D on Y and D on T, conditional on X and f(L) as shown by Hahn et al. (2001).

While β has all the usual properties of an IV estimator, it reflects only a Local Average Effect (LATE) of the MADB scheme for farmers around the threshold. Therefore, the estimated treatment effects to smaller and larger farmers is needed to satisfy the required external validity assumptions. For example, smaller and larger farmers are not expected to face the same degree if credit rationing, which would imply heterogeneous marginal effects of credit on productivity. Nonetheless, this threshold is the land size of the 60th centile farm household in our sample and located between the firm size of the average (11.6) acre and median 8 (acre) households. This suggest that the LATE estimates are relevant at least for the "average farm" in the distribution of rice holding.

However, the test for validity of the regression discontinuity (RD) design approach should begin with a graphical presentation and provide evidence of whether or not there is a discontinuity at the cut-off point. This study uses graphs to examine the discontinuity of treatment and outcome variables at the threshold. This study then confirms the visual examination using reduced form estimates which are the effects of the treatment binary indicator D on the treatment and outcome variables. Figure 3.1 illustrates the first-stage relationship between the amount of credit per acre received by farm households from the MADB and their landholding size. The actual cultivated land size is not appropriate to use for determining credit per acre, as it might be endogenous to the treatment. For example, the availability of credit allows farmers to use more inputs and hire more labour and, therefore, can allocate a larger share of their available land to rice cultivation. In this study, household's landholding size, which is exogenous to the credit scheme, is used to estimate the impact of credit on rice production.

The graph clearly presents the evidence of a discontinuity at the cut-off point (10 acres of land size) between households that have more than 10 acres of land and households that have less than or equal to 10 acres of land. In particular, the gap between the polynomial fitted lines present the Local Average Treatment Effect (LATE). As can be seen in the graph, there is an apparent increase in the amount of credit per acre before the cut-off point. However, it consistently drops down beyond the cut-off point when the land sizes become large. This graph, however, clearly demonstrates a non-linear relationship between credit per acre and land size on each side of the cut-off point, and the evidence of discontinuity at the cut-off point. Specifically, the amount of credit per acre significantly decreases from 80,000 Kyat per acre at the discontinuity to below 20,000 Kyat per acre at 70 acres of cultivated land size.

Fig. 3.1 Relations between credit per acre and land size

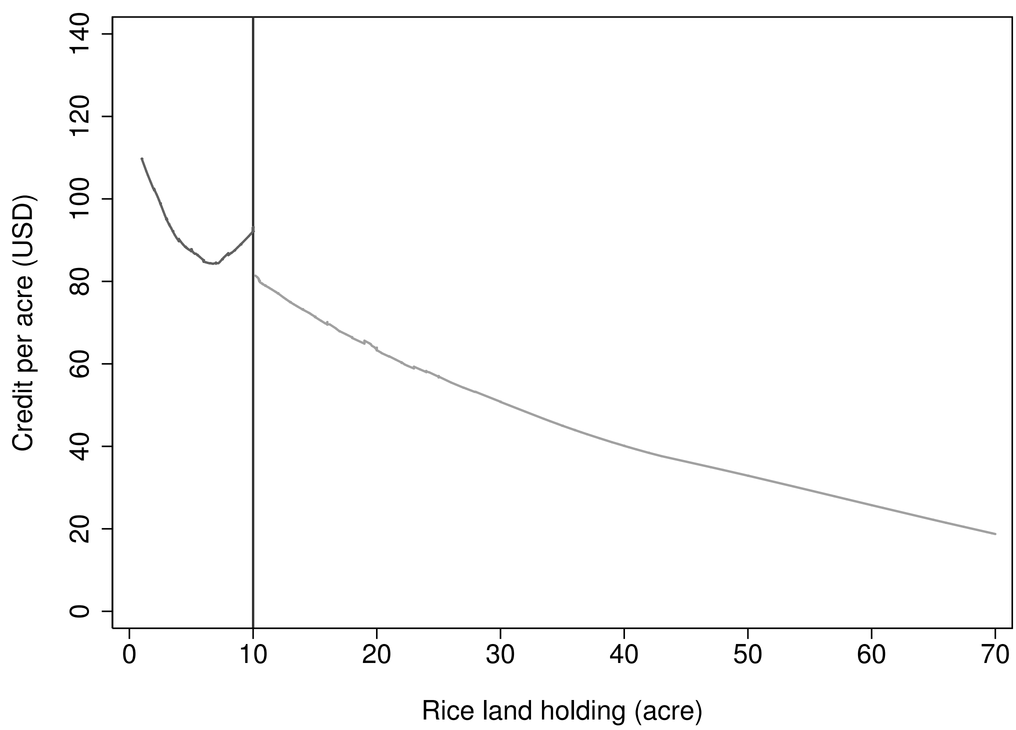
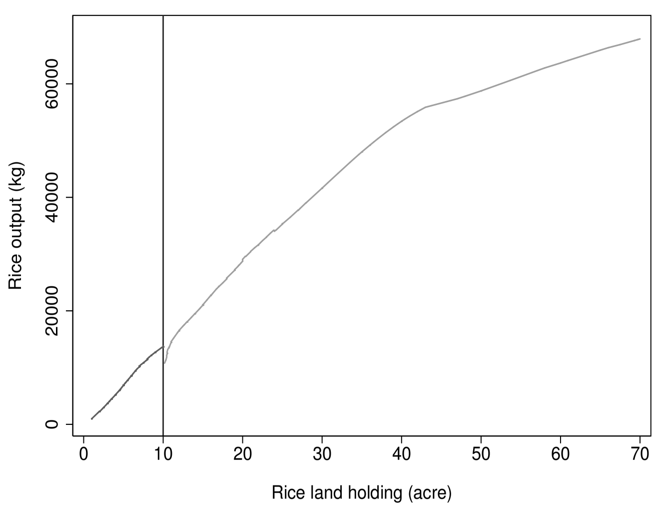
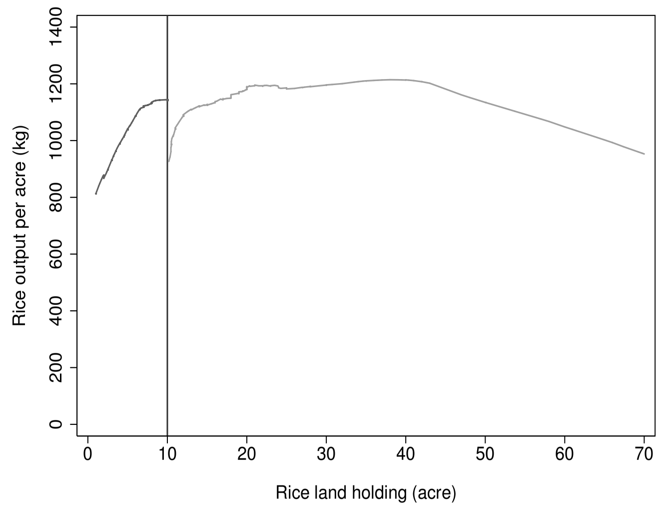


Figure 3.2 (a) and (b) present rice output against landholding size of farm households, and rice output per acre against landholding size respectively.

Fig. 3.2 Rice output and output per acre: evidence of discontinuity



(a) Rice output against landholding size



(b) Rice output per acre against landholding size

As illustrated in Figure 3.2 (a), there is a positive relationship between rice output and landholding size. There is a clear discontinuity at the cut-off point or 10 acres of land size. Figure 3.2 (b) also shows that rice production increases dramatically in accordance with increased land size until 10 acres of land is reached. Rice production, however, increases with the decreasing rate beyond the cut-off point. Consistent with Figure 3.1 and Figure 3.2 (a), Figure 3.2 (b) shows a clear discontinuity at the cut-off point.

The baseline characteristics of the participants in the treated group and control group is used to satisfy the key assumption of using the RD approach [6]. Under this assumption, there is not much difference in the characteristics between those groups at the baseline (Ikenwilo et al., 2016). In this study, household characteristics including age, gender, farming experience, educational level of household head, the number of household labours and the dependency ratio, the irrigation system, the agricultural extension services, the effect of regions and the distance from village to township are tested for balancing.

Table 3.3 presents the results of mean values, standard deviation, mean difference and statistical significance of the difference of each variable for farm households between less than 10 acres of land holding and more than 10 acres of land holding. For household characteristics, the variables for age, gender, educational level of the household head, farming experience and number of household labours are not statistically significant differences between a group with holding more than 10 acres of land and a group with holding less than 10 acres of land. In contrast, the differences in mean value for dependency ratio of each household is statistically significant at 5 per cent level.

The dependency ratios are 43 per cent and 48 per cent for households with holdings of land up to 10 acres and larger than 10 acres respectively. Likewise, the differences in mean values for other variables such as irrigation, region and the distance to a township's bank branch are also statistically significant at the 1 per cent level, but agricultural extension services is not significant. Accordingly, these variables might explain the effects of heterogeneity in the treatment variable, and they should be controlled for the estimation of regression analysis. Therefore, the baseline characteristics of farm households in a group of larger land size are likely to be compared with those in a group of smaller land size.

[6] In this study, farms with holdings of larger than 10 acres are categorised as the treated group, whereas farms with holdings of less than 10 acres are defined as the control group.

Table 3.3 Baseline characteristics of the farm household with holdings of land size

Variable	Household with holdings of (≤10 acre)		Household with holdings of (>10 acre)		Test statistics	
	Mean	Std. Dev	Mean	Std. Dev	Diff	P value
Output (kg)	8117.25	297.22	30247.03	1400.16	22129	0.000***
Rice output per acre (kg)	1055.77	21.81	1146.86	24.74	91.09	0.009***
Rice income (000 kyat)	1670.22	1143.52	6344.00	4621.03	4673.79	0.000***
Total income (000 kyat)	2503.04	1426.83	7671.96	5480.56	5168.92	0.000***
Landholding size (acre)	7.21	0.19	25.86	1.01	18.65	0.000***
Credit per acre (000 kyat)	86.00	42.48	57.48	27.18	28.53	0.000***
Household head						
Age	50.73	0.61	51.76	0.74	1.03	0.294
Gender	1.04	0.01	1.05	0.01	0.01	0.975
At most primary	0.64	0.48	0.57	0.50	0.07	0.089
Secondary education	0.25	0.43	0.27	0.44	-0.02	0.582
High school (or) higher education	0.11	0.32	0.16	0.37	-0.05	0.081
Farming experience	27.36	0.65	28.93	0.77	1.56	0.139
Number of household labours	2.90	1.45	2.92	1.65	0.02	0.863
Dependency ratio	0.43	0.01	0.48	0.02	0.05	0.015**
Irrigation service	0.78	0.02	0.90	0.02	0.13	0.000***
Agricultural extension services	0.58	0.02	0.58	0.33	0.002	0.963
Region	0.57	0.02	0.86	0.02	0.28	0.000***
Distance to township's bank branch	18.54	1.10	14.20	0.87	4.34	0.008***
Total farm households (N)	413		221			

Notes : *, ** and *** correspond to statistical significance at 10%, 5% and 1% levels respectively.

3.5.3 Selection of the appropriate model specification for the RD approach

As discussed earlier, it is best to begin with a graphical presentation to provide the visual patterns for both the relationship between land size and credit per acre, and the relationship between land size and rice output. In general, there are two approaches for the regression discontinuity, namely the parametric approach and non-parametric approach. Due to the small sample size and there being no critical large number of data around the cut-off point, the parametric approach should be used for the primary estimation in this study (Jacob et al., 2012). Accordingly, the parametric approach is applied to the estimation of the treatment effect on a functional form for that relationship, and selection of an appropriate model. The equation of functional form is as follows:

$$Y_i = \sum_{j=1}^{3} \beta_j L_i^j + \delta T_i + X_i \alpha + \lambda_1 IRRI_i + \lambda_2 REGION_i + \lambda_3 DIST_i + \varepsilon_i \quad (3.3)$$

Where Y_i is the outcome variable (rice output and measure in kg), T_i is the amount of credit per acre received by an individual farm household. Household's landholding size is used to measure the amount of credit per acre, as the loan approval is made based on the acreage of holding paddy land size. The actual cultivated land size might be different due to weather conditions, irrigation, and the self-selection of households. X_i is a vector of farm i household characteristics (age, gender, educational level of household head, household size and dependency ratio, and agricultural extension services), irrigation service, the effect of regions (Delta Region and Dry Zone), access to a township's bank branch, and L_i represents household's holdings of land acreage with third-degree polynomial and ε_i is an unobserved error term.

If farm households mainly depend on land size for receiving loans, the relationship between the treatment status (T) and assignment rule might be deterministic. As mentioned previously, the sharp design is appropriate to apply for the analysis if the deterministic relationship exists. However, there is no finding for this relationship between treatment status and assignment variable in this study. Specifically, some farm households receive more than the maximum eligible amount, although their land sizes are below the cut-off point ($L_i \leq 10$). In contrast, some farm households that own more than 10 acres of land or above the cut-off point (L_i >10) do not receive the eligible amount of the credit scheme.

Table 3.4 shows the treatment status of the credit scheme and farm's land-holding size. Of 413 farm households with holdings less than 10 acres of land, nearly 57 per cent applied and received credits, while 8 per cent did not apply for the credits from the MADB. Likewise, 33 per cent of farms having more than 10 acres applied and received credits, while 1 per cent of households did not apply for the credits. In this connection, the assignment variable to treatment status mainly relies on the farm's holding land size in a stochastic manner that suggests the FRD approach.

Table 3.4 Treatment status of credit by farm households

Application of credit	Status		Total
	Treated Group	Control Group	
Applied	364 (57%)	213 (33%)	577 (91%)
Not applied	49 (8%)	8 (1%)	57 (9%)
Total	413 (65%)	221 (35%)	634 (100%)

Notes : household with holding of land (≤10) acre is under treated group, while household with holding of land (>10 acre) is under control group.

In order to analyse the impact of credit policy on rice production, an instrumental variable (IV) approach is appropriate in the fuzzy regression discontinuity design (Hahn et al., 2001). Theoretically, the discontinuity can be used as an instrument variable for the treatment effect. Additionally, the local linear regression or the polynomial regression is suitable to use for estimation of the value of discontinuity for a continuous assignment variable in the regression (Lee and Lemieux, 2009). The OLS regression estimates the first-stage equation (reduced form) and predicts the coefficient of treatment $\hat{T_i}$. This value is placed at (T_i) in the second-stage equation (structured form) for the estimation of the coefficient of treatment. Accordingly, a farm household's land size is applied as an instrument variable to estimate the effect of the credit policy. In the reduced form, the credit per acre is a function of an instrument variable (Z_i), a third–degree polynomial of land holding size at the cut-off point (L_i), and controls household level covariates (X_i).

The reduced form of credit per acre as a function of land size is as follows at the first stage:

$$T_i = \sum_{j=1}^{3} \beta_j L_i^j + \gamma Z_i + X_i\alpha + \lambda_1 IRRI_i + \lambda_2 REGION_i + \lambda_3 DIST_i + \nu_i \quad (3.4)$$

where T_i is the amount of credit per acre received by an individual farm household, Z_i is the instrument variable, and it takes the value of 1 if farm household has a maximum of 10 acres of land and Z_i is 0 if otherwise. L_i is land size owned by an individual farm household and ν_i is the residual. The predicted coefficient of $\hat{T}_i$ is taken into the second-stage equation for its effect on rice output. However, the unobserved characteristics that capture rice production are uncorrelated with the instrument variable, and that is required to identify the assumption as $E(Z_i\ \mu_i \setminus X_i,\ L_i)$=0. Under this assumption, the credit program is estimated in the second stage (structured form) as

$$Y_i = \sum_{j=1}^{3} \beta_j L_i^j + \delta \hat{T}_i + X_i\alpha + \lambda_1 IRRI_i + \lambda_2 REGION_i + \lambda_3 DIST_i + \varepsilon_i \quad (3.5)$$

This study analyses the full sample, sub-samples with holdings of land (0-20) acres, (5-15) acres and (8-12) acres to estimate the impact of credit on rice production. To identify the power of the instrumental variable, the regression of the threshold indicator variable D and land holding size polynomial on the X variables is as

$$X_i = \lambda_0 + \lambda D_i + \lambda_1 L_i + \lambda_2 L_i^2 + \lambda_3 L_i^3 + u_i \quad (3.6)$$

Following Lee and Lemieux (2010), the balancing tests on observables X for the full sample and sub-samples controlling for a third polynomial landholding size are presented in Table 3.5. The estimates of this study are obtained using data in intervals c $\pm$ h around the threshold c where c=10 acre and h is a bandwidth suitable for comparing the ‘treatment’ and ‘control’ groups. A relatively small interval around the household will reduce estimation precision due to having too few observations. Taking a wide interval may resolve this but also introduce bias from farms that are far from the threshold and unsuitable comparisons for the farms below the threshold.

To address this trade-off, this study selects an interval such that it facilitates both balancing feature of the sample and the identifying power of the instrumental variable, but limits the loss of observations and precision of the estimates. This study, therefore, analyses several intervals around the threshold, the largest being 0-20 acres with the biggest sample size. However, the existing literature suggests that small farmers tend to use MADB credit for subsistence (LIFT, 2012), and it is, therefore, hard to disentangle the impact of credit on rice production from subsistence consumption. Taking a smaller interval, at 5-15 acres and 8-12 acres of land, would avoid this problem by excluding the smallest farmers but also reduce the sample size. For intervals closer around the threshold, the instrument loses statistical power, presumably due to sample size.

Balancing test results are presented in Table 3.5. Controlling for a third order polynomial of land size, the full sample shows a few statistically significant differences between households below and above the threshold in X. Farmers above the threshold report on average lower quality irrigation systems, are more likely to live in the Dry Zone and less likely to live in Delta Region. When we focus on the symmetric intervals around the 10-acre threshold, then the statistical significance disappears, except for 5-15 and 8-12 acre intervals. These results suggest that the factors that matter for the outcome are continuous in the assignment variable, D_i. There is little significant difference between households below and above the threshold in X, suggesting that the landholding size is appropriate for an instrument variable in this case.

Table 3.5 Balancing tests of household characteristics

VARIABLES	Full sample	0-20	5-15	8-12
Household head				
Age	1.29	-1.20	-2.16	0.97
	(1.65)	(2.56)	(2.82)	(3.06)
Gender (1=male)	0.05	0.02	0.01	-0.02
	(0.03)	(0.06)	(0.07)	(0.07)
At most primary	-0.05	-0.11	-0.04	0.15
education (1=yes)	(0.09)	(0.12)	(0.12)	(0.18)
Secondary education	0.06	0.09	0.10	0.01
(1=yes)	(0.09)	(0.10)	(0.13)	(0.15)
High school/	-0.01	0.02	-0.05	-0.16*
higher education (1=yes)	(0.05)	(0.07)	(0.08)	(0.09)
Farming experience	0.21	-1.90	-2.34	1.82
	(1.96)	(2.98)	(2.82)	(3.38)
Household labour	0.02	-0.06	0.04	0.75
	(0.24)	(0.32)	(0.42)	(0.42)
Dependency ratio	-0.003	0.01	0.01	-0.06
	(0.03)	(0.04)	(0.05)	(0.07)
Irrigation deemed good	-0.14***	-0.13*	-0.17	-0.21**
/very good (1=yes)	(0.05)	(0.07)	(0.11)	(0.11)
Agricultural extension services	-0.01	-0.14	0.16*	0.12
(1=yes)	(0.07)	(0.10)	(0.10)	(0.17)
Distance to market (km)	1.14	2.86	5.23	14.07
	(2.93)	(3.55)	(6.08)	(12.37)
Delta Region (1=yes)	-0.16**	-0.17	-0.23	-0.46**
	(0.07)	(0.11)	(0.15)	(0.21)
Observations	634	537	293	149

Notes : 1) *, ** and *** correspond to statistical significance at 10%, 5% and 1% levels respectively. 2)Standard errors are presented by number in parentheses.

3.6 Results

3.6.1 Estimates of the full sample specification

Credit policy in Myanmar focuses mainly on small farm holders; therefore, the provision of credit cannot be assumed to be random under this policy. Unobserved characteristics such as soil quality, weather conditions and loan amounts from other sources may generate positive effects on the yield of rice paddy; therefore, OLS estimates of credit received are likely to lead an overestimate. In order to control for those factors, the instrumental variable (IV) is created to estimate the effects of the credit program on rice production. As mentioned earlier, the status of land ownership is used as an IV, and takes the value of 1 for farms with holdings of at most 10 acres of land or the value of 0 for those with holdings of more than 10 acres.

Firstly, this study analyses the impact of credit per acre on rice production, rice output per acre, rice income and total income for the whole sample size. Table 3.6 shows the results for the first stage regression and reduced form regression. The result of the first stage regression shows a negative correlation between the amount of credit per acre and the threshold indicator variable (Z) (holdings larger than 10 acres of land). However, the coefficient is not significant. Similarly, there is no effect of landholding size on rice output as the coefficient of threshold indicator (Z) is not significant.

Table 3.6 First stage and reduced form regressions of full sample

Variable	First stage	Reduced form
CONS	119.02***	5000.14
	(14.27)	(5497.47)
Acres landholding > 10	-6.41	-143.20
(Z)	(5.70)	(1134.96)
Acres landholding	-2.14	1024.84***
(LAND)	(1.59)	(176.95)
Acres landholding squared	0.02	18.75*
(LAND2)	(0.05)	(10.61)
Acres landholding cubed	0.0001	-0.30**
(LAND3)	(0.0005)	(0.14)
AGE	0.03	1.04
	(0.14)	(35.77)
GENDER	-1.99	-2319.71
	(5.66)	(2256.62)
HHLAB	0.24	-668.54
	(1.17)	(441.94)
DEPENDENCY	0.21	-5083.33*
	(8.43)	(2930.26)
SECONDARY EDUCATION	2.87	503.25
	(2.65)	(1121.88)
HIGHER EDUCATION	6.10	-469.88
	(6.14)	(1939.83)
AES	-2.83	886.47
	(3.22)	(1078.89)
IRRI	-3.63	-11.18
	(4.53)	(693.52)
DIST	-0.81***	-34.21
	(0.24)	(57.07)
REGION	-5.58	5238.10***
	(6.62)	(1399.48)
R^2	0.34	0.72
N	634	634

Notes:1) *, ** and *** correspond to statistical significance at 10%, 5% and 1% levels respectively. 2)Standard errors are presented by number in parentheses.

Table 3.7 Instrumental variable regressions of full sample

Variable	Rice output (kg)	Rice output (acre)	Rice income (Kyat)	Total income (000 Kyat)
(1)	(2)	(3)	(4)	(5)
CON	2341.12	-625.65	-1072.88	-6744.86
	(21848.74)	(1945.84)	(4650.98)	(10941.18)
Acres landholding > 10	22.34	12.59	20.59	77.98
(Z)	(179.33)	(15.05)	(38.47)	(86.36)
Acres landholding	1072.66**	35.47	283.27**	416.17
(LAND)	(501.76)	(54.74)	(117.87)	(322.12)
Acres landholding squared	18.39*	-0.31	3.30	5.88
(LAND2)	(10.77)	(0.96)	(2.56)	(6.73)
Acres landholding cubed	-0.30**	-0.001	-0.05**	-0.11**
(LAND3)	(0.14)	(0.01)	(0.03)	(0.06)
AGE	0.39	-1.82	-8.76	-12.25
	(36.64)	(2.89)	(9.43)	(17.02)
GENDER	-2275.26	-1.28	2.62	-200.41
	(2387.94)	(178.35)	(409.43)	(720.39)
HHLAB	-673.94	-12.90	-172.28**	20.23
	(455.16)	(25.63)	(80.60)	(135.24)
DEP	-5088.05*	-112.99	-927.91	-1028.77
	(3039.34)	(194.18)	(694.30)	(1136.19)
EDU3	439.08	7.70	118.75	162.59
	(1223.53)	(67.95)	(222.19)	(445.04)
EDU45	-606.22	-89.61	-217.42	-404.89
	(2358.49)	(154.37)	(470.97)	(875.12)
AES	949.61	81.27	310.29	343.29
	(1194.44)	(86.88)	(279.58)	(468.67)
IRRI	69.99	201.88*	501.57*	644.76
	(922.99)	(111.94)	(262.69)	(521.89)
DIST	-16.06	8.42	5.91	39.97
	(160.22)	(14.97)	(36.24)	(77.62)
REGION	5362.66***	402.75**	-248.01	-547.64
	(1833.63)	(192.53)	(683.94)	(1014.44)
R^2	0.71	0.56	0.69	0.26
N	634	634	634	634

Notes : 1) *, ** and *** correspond to statistical significance at 10%, 5% and 1% levels respectively. 2)Standard errors are presented by number in parentheses.

The IV estimator of credit on rice output in Equation 3.5 is provided in Table 3.7, column 2. The result does not provide any evidence of the effect of credit per acre on rice production. Column 4 and column 5 of Table 3.7 show the effect of credit per acre on rice income, and total income respectively. However, there is no impact of credit per acre on both rice income and total income of rural households in the selected regions. The possibility might be the effect of a large difference in landholding sizes among farm households and larger standard errors that drive the weak instrument for the full sample.

Under the MADB's credit scheme, farm households are eligible to apply for paddy loans from the MADB for up to 10 acres of land. However, the actual cultivated land size might differ from the landholding size, as farm households could make decisions based on irrigation, weather and plant disease. Most farmers in the Dry Zone are more interested in the other non-rice crops, such as pulses, beans, peanuts and sugarcane because of less demand for water and increased demand of these crops. In this connection, the credit per acre received by some farm households is more than 100,000 Kyat. Of 577 farm households that applied for credits from the MADB, nearly 32 per cent of those farmers had more than 100,000 Kyat of credit per acre in this study.

3.6.2 The results for farm households with various landholding sizes

This section discusses the sub-sample of farm households with different landholding sizes, as the threshold variable has no strong evidence of its impact on the amount of credit per acre for the full sample. To minimize the cofounding effects associated with small and large rice output, farm households with holdings 0-20 acres of land, 5-15 acres of land and 8-12 acres of land are analysed to estimate the effect of credit policy.

Table 3.8 shows the results of the first stage form of Equation 3.4 for landholding size of 0-20 acres, 5-15 acres and 8-12 acres. There is a clear effect of the threshold variable on the credit amount per acre at different intervals around the discontinuity. If the farms owned more than 10 acres of the cultivated land, they would receive 100,000 Kyat (USD 100) less per acre on the average amount of credit. The correlation between the treatment (credit per acre) and instrument (landholding size) is negative and significant at 5 per cent for 5-15

Table 3.8 First stage regressions for credit per acre at different intervals

Variables	Land size (acre)		
	(0 – 20)	(5 – 15)	(8 – 12)
Constant	124.33***	196.99**	3368.14*
	(24.06)	(88.32)	(2032.41)
Acres landholding > 10	-21.20***	-16.96**	-26.63***
(Z)	(5.22)	(6.71)	(12.74)
Acres landholding (LAND)	-15.29*	-43.54	-1012.00*
	(9.04)	(30.10)	(618.95)
Acres landholding squared	1.67*	5.19*	102.32*
(LAND2)	(0.94)	(3.15)	(61.77)
Acres landholding cubed	-0.05*	-0.19*	-3.39*
(LAND3)	(0.02)	(0.10)	(2.02)
Observations	537	293	149
R^2	0.04	0.05	0.07
F	5.47	8.16	3.74

Notes : 1) *, ** and *** correspond to statistical significance at 10%, 5% and 1% levels respectively. 2)Standard errors are presented by number in parentheses.

acres, and 1 per cent for 0-20 acres and 8-12 acres.

The results are consistent with Figure 3.1, and state that the farm households with holdings of more than 10 acres of land are associated with a decline in the average amount of credit per acre from 7,000 Kyat (USD 7) up to 10,000 Kyat (USD 10). These results strongly indicate that the status of landholding size is relevant as an instrumental variable in analysing the impact of credit policy on rice production in Myanmar.

Table 3.9 shows the reduced form regressions of the threshold indicator (landholding size) on rice output, rice output per acre, rice income and total income for farm households with holdings small interval at 8-12 acres of land. The coefficient of threshold variable (Z) is not statistically significant for rice output, rice output per acre, rice income and total income. For this small interval around the threshold, there is no significance in reduced form, presumably due to a few observations.

Table 3.9 Reduced form regressions (8-12 acres)

Variables	Rice output (kg)	Rice output per acre (kg)	Rice income (000 Kyat)	Total income (000 Kyat)
Constant	-22632.44	3397.60	-65698.46	2490.08
	(415133.30)	(21811.87)	(91703.53)	(76312.37)
Acres landholding >10	-2476.20	-244.37	32.78	-377.35
(Z)	(2943.32)	(179.27)	(742.97)	(637.72)
Acres landholding	12629.46	-592.89	20401.70	-102.98
(LAND)	(125917.60)	(6504.27)	(27685.02)	(23163.94)
Acres landholding	-1583.41	45.41	-2020.73	37.60
squared (LAND2)	(12568.22)	(637.60)	(2743.59)	(2316.71)
Acres landholding	68.30	-0.86	66.53	-1.35
cubed (LAND3)	(412.47)	(20.53)	(89.26)	(76.31)
Observations	149	149	149	149
R^2	0.04	0.04	0.03	0.01
F	1.87	0.63	2.07	0.89

Notes : 1) *, ** and *** correspond to statistical significance at 10%, 5% and 1% levels respectively. 2)Standard errors are presented by number in parentheses.

Table 3.10 provides the estimates of the effect of credit amount per acre on rice production, rice output per acre, rice income and total income by controlling third polynomial land size. The IV estimates of MADB credit do not have any significant effect on all outcomes. The possible reason is no significance in the reduced form regression due to a few number of farm households at an interval of 8-12 acres of land.

The IV estimate of the credit program on rice production can be manually calculated as the ratio of the value of the reduced form coefficient to the value of first stage regression coefficient from column 2 of Table 3.9 and column 2 of Table 3.8 (-2,476.20/-26.63 =92.96). The result of this estimate is consistent with the estimate of local average treatment effect (LATE) from the 2SLS approach that is displayed in column 2 of Table 3.10. When the 2SLS approach is used, the result shows little evidence of relationship between credit per acre

Table 3.10 Instrumental variable estimates without control variables (8-12 acres)

Variable	Rice output (kg)	Rice output per acre (kg)	Rice income (000 Kyat)	Total income (000 Kyat)
CONS	-335736.3	-27501.06	-61553.45	-45222.66
	(384296.80)	(19402.63)	(79011.28)	(80413.93)
Credit per acre	92.96	9.17	-1.23	14.17
	(106.93)	(6.84)	(28.12)	(21.80)
LAND	106705.6	8691.01	19156.27	14232.94
	(117343.6)	(5843.86)	(24229.30)	(24710.15)
LAND2	-11094.67	-893.21	-1894.81	-1411.78
	(11933.67)	(589.91)	(2482.72)	(2535.81)
LAND3	383.27	30.22	62.37	46.65
	(400.48)	(19.68)	(4.85)	(85.96)
N	149	149	149	149
F	1.81	0.71	2.08	0.88

Notes : 1) *, ** and *** correspond to statistical significance at 10%,5% and 1% levels respectively. 2)Standard errors are presented by number in parentheses.

and rice production.

Table 3.11 shows the estimates with controlling for household characteristics, agricultural extension services and irrigation, and regional characteristics. Similar to the estimates with controlling for a third degree polynomial of acres land holding, the results show no evidence of MADB credit impacts on rice output, rice output per acre, rice income and total income for those who have 8 to 12 acres of land size.

The reduced form regressions for the 0-20 and 5-15 acre landholding interval is presented in Table A3. Similar to the result of 8-12 acres of land size, there is no statistically significance in difference for farms on either side of the threshold. However, the coefficients for total income for both the interval of 0-20 and 5-15 acres are statistically significant at 5 per cent level.

Table 3.11 Instrumental variable estimates with control variables (8-12 acres)

Variable	Rice output (kg)	Rice output per acre (kg)	Rice income (000 Kyat)	Total income (000 Kyat)
Credit per acre	-46.66	6.49	14.94	51.77
	(191.04)	(12.75)	(50.42)	(73.56)
Control variables				
Land size polynomial[a]	Yes	Yes	Yes	Yes
Household characteristics [b]	Yes	Yes	Yes	Yes
Irrigation [c]	Yes	Yes	Yes	Yes
Regional characteristics [d]	Yes	Yes	Yes	Yes
N	149	149	149	149
R^2	0.50	0.06	0.49	0.41
F	50.68	4.99	38.38	41.75

Notes: ([a]) Cultivated land size polynomial: a third degree polynomial of cultivated land size (acres); ([b]) Farm and personal characteristics: Household head's age, gender, education levels, number of household labours, dependency ratio. ([c]) availability of extension services and Irrigation: access to very good/good irrigation. ([d]) Regional characteristics: Distance to the market and regional dummy variables for Sagaing (Dry Zone), Bago (Delta Region) and Ayeyarwady (Delta Region). Standard errors are presented by number in parentheses. *, ** and *** correspond to statistical significance at 10%, 5% and 1% levels respectively.

The results of credit on the sub-sample of 0-20 and 5-15 acres of landholding size (with or without controls) are presented in Table A4 and Table A5 respectively. Tables show a little impact of credit per acre on rice production, rice yield, income from rice and total income for all sub-sample of around the discontinuity point.

In general, this study finds no convincing evidence of MADB credit impacts on yield. The lack of impact on rice yield is the possible focus of rice farmers on producing high-quality rice. As described in Chapter 2, Ayeyarwaddy and Sagaing are the two largest regions producing Paw San rice, which is recognized as one of the world's most high-quality rice. The adoption of this variety remains relatively limited, however, since it requires more input and is more labour intensive while having a lower yield than other varieties (Myint and Napasintuwong, 2016). Meanwhile, Paw San rice is priced about 33-36 percent higher and enjoys more demand than other rice (Myint and Napasintuwong, 2016). In this situation, it is the rice income rather than rice output or rice yield that is relevant for farmers. Having said that, there is no evidence of MADB credit impacts on rice income. Again, this result is robust regardless of whether controls are included or not.

Table A6 presents the relationship between credit per acre and household's total income. This study finds statistically significant effects of MADB credit on total income for 0-20 and 5-15 acres with or without control variables. The estimates are larger in magnitude for the 5-15 acres land holding interval as compared to that of 0-20 acres. The results remain robust although control variables for farm characteristics, irrigation and regional characteristics are included.

As is seen in Table A6, there is a positive effect of credit on total farm income for an interval of 0-20 or 5-15 acres, possibly reflecting the fungibility of money. Farms plant rice because they are not in a position to make an alternative crop choice when it comes to rice land, at least not in the short term, since their crop choices are bounded by their land use certificates which require them to plant rice in at least one season. They, therefore, optimize their total farm income, not rice income or output specifically. They could have used the option of cheap credit for rice production to fund other activities that generate more profit.

3.6.3 Robustness checks

In the FRD design, the non-parametric regression approach is used to estimate the local average treatment effect (LATE) choosing a small neighbourhood (bandwidth) on both sides of the cut-off point. In addition, this design uses the data within the bandwidths to estimate the ratio of two differences between the treated group and the non-treated group at that cut-off point for both the outcome and treatment regressions (Imbens and Lemieux, 2008). The ratio of the two discontinuities can be estimated as

$$\beta_{RDD} = \frac{E(Y_i \backslash \bar{l} \geq \; L_i > \bar{l} - \psi) - E(Y_i \backslash \bar{l} < \; L_i \leq \bar{l} + \psi)}{E(T_i \backslash \bar{l} \geq \; L_i > \bar{l} - \psi) - E(T_i \backslash \bar{l} < \; L_i \leq \bar{l} + \psi)} \tag{3.7}$$

Where Y is the output variable (rice output), T is the treatment variable (credit per acre), L_i is the total holding land size of an individual household, and l is the rating variable or the land size (10 acres) at the cut-off point. According to Lee and Lemieux (2010), the results of the sensitivity of IV estimation allow for the changes in the interval of assigned land size because different bandwidth might show the different estimates. Following Lee and Lemieux for the FRD with varying interval, Table A7 in Appendices displays the results of IV-2SLS regressions including the covariates. Meng (2013) explained that the instrumental variable should produce insignificant 2SLS estimates between the treated group and non-treated group if there were no differential trends around the cut-off point. In this study, the robustness checks are estimated with different intervals of land size with (± 0.5 acre, ± 0.1 acre and ± 1.5 acre), specifically, the IV estimates of land size for 9.5-10.5, 9-11, and 8.5-11.5 by determining with covariates. The covariates used in the robustness checks are the same variables of the main specification model. The specifications for different intervals of acre for (± 0.5 acre, ± 0.1 acre and ± 1.5 acre) are shown in columns 2, 3 and 4 in Table A7 respectively. None of those coefficients of β with bandwidths between 8.5 and 11.5 are statistically significant, suggesting that there is no difference in farm households with holdings land size around the cut-off point.

3.7 Conclusion

In an attempt to promote the development of agricultural sector and rural areas in Myanmar, the MADB is the main financial institution providing agricultural loans throughout the country. Due to the lack of sufficient capital, there are some limitations on loans provided by the MADB. In recent years, the MADB bi-annually has lent 100,000 Kyat per acre for paddy for a maximum of 10 acres at an interest rate of 8.5 per cent per year. Under this framework, farm households with holdings of up to 10 acres can benefit from the policy as they receive an amount of credit in accordance with their landholding size. In other words, the MADB mainly supports smallholder farmers compared to farmers with medium or large holdings. Large farm holders, therefore, can receive only loan amounts for up to 10 acres of their land. In order to address the impact of credit on rice production, this study has investigated how the credit program might help increase rice production in the selected households.

Since the provision of credit is based on the landholding size of a farm household, a fuzzy regression discontinuity (FRD) approach has been applied to investigate the effect of credit policy on rice production in this study. The graphs clearly present the discontinuity points between rice output and land size, as well as between credit per acre and land size. Findings show that farmers who have a maximum 10 acres of land are likely to have comparable baseline characteristics with farmers who have more than 10 acres. Furthermore, the results of robustness checks confirm the validity of regression discontinuity. The status of land size is constructed as an instrumental variable to estimate its effect on the amount of credit per acre. The results for full sample do not show any impact on credit per acre on rice output and rice income.

This study takes the symmetric intervals around the thresholds, especially 8-12 acres, 5-15 acres and 0-20 acres of land to analyse the impact of credit on rice production. The results from the first stage regression for landholding size of 5-15 acres is significant at the 5 per cent level, and 0-20 acres and 8-12 acres are significant at 1 per cent levels, suggesting that the status of land size seems to be appropriate to use as an instrumental variable in this research. the result for an interval of 8-12 acres of land show no statistically significant the effect of MADB on rice output, rice income and total income with or without control for agricultural extension services, irrigation, and regional characteristics. Nonetheless, there is an impact of the program on total household income for landholding sizes of 0-20 and 5-15 acres with and without control covariates, suggesting its positive spillover effects on other farm income activities.

Although different methodologies were used to analyse the impact of credit on rice productivity, the result of this study was contrary to those found by Aktaruzzaman (2013) and Nan Wutyi et al. (2013) who found evidence of the impact of credit on the small farm size group. All in all, this study finds little evidence of MADB credit impacts on rice output and rice income in the selected regions. On the other hand, a production cost of approximately 150,000 Kyat (USD 150) to 400,000 Kyat (USD 400) per acre in this study confirms that the current availability for loans provided by MADB covers half of the production cost per acre. Due to an insufficient amount of credit for production cost per acre, farmers cannot use quality seeds and the required amount of fertilizers, and many of them decided to borrow money from local money lenders at much higher interest rates. As a result, farmers cannot improve rice productivity or increase their income. The MADB, therefore, should take into account the cost of production and provision of the amount of loans to help increase productivity, reduce poverty and develop rural areas.

Based on insights from this paper, the MADB should take full responsibility of the process for credit screening and loan-making decisions. Importantly, the MADB should provide agricultural loans without limits on land size and encourage large farm holders to improve their productivity. For farmers who have more than 10 acres of agricultural land size should receive more credit with respect to their landholding size to cover the cost of rice production. Under the limited farm size policy of the MADB results in having burden to get more lenders who charge 5 to 20 per cent interest per month for loans. With regards to the repayment of loans, the MADB should reconsider the loan collection period as the full repayment is expected during harvest time.

According to the current repayment rule, farmers are not able to keep and sell the rice output until the price of rice increases. The income of farmers may increase if they can sell their product at higher prices. The longer the farm households can hold rice output, the higher the income and the more profit they have. On the other hand, the government should allow the MADB to have some relief from the rule that the MADB has to transfer 75 per cent of its profits to the state, and help raise sustainable capital for the MADB. In doing so, the MADB is likely to release its constraints, such as provision of loans for limited crops, the amount of credit per acre and land size in the near future. More importantly, the government should re-establish village banks that might help farmers to save travelling time and transportation costs for access to credit.

However, there are some limitations in this study that should be accounted for future research. Although the status of land size is used as an instrument variable to investigate the effect of credit programs, there is a need for the analysis of effects of regional characteristics. By understanding the role of credit in rice production, therefore, the estimates of performance of firms in different regions should be separately considered for achieving higher levels of rice production in the selected regions.

3.8 Appendices

Table A1: Summary statistics for farm households with landholding of $\leq$ 10 acres

Variable	Units	Mean	Std. Dev	Min	Max
Output(kg) (Y)	kg	8117.25	6040.17	209.00	35530
Output per acre	kg	1055.77	443.31	104.50	2299
Landholding size (LAND)	acre	5.85	2.50	1.00	10
Age of household head (AGE)	years	50.73	12.29	22.00	86
Gender of household head (GENDER)	male=1	1.04	0.20	1	2
At most primary education (EDU12)	yes=1	0.64	0.48	0	1
Secondary education (EDU3)	yes=1	0.25	0.43	0	1
High school/ higher education (EDU45)	yes=1	0.11	0.32	0	1
Experience of household head (EXP)	years	27.37	13.25	2.00	65
Household labour (HHLAB)	number	2.91	1.45	1	10
Dependency ratio (DEP)	ratio	0.43	0.23	0	0.86
Irrigation services (IRRI)	rank	0.78	0.42	0	1
Agricultural extension services (AES)	yes=1	0.58	0.49	0	1
Region (REGION)	Delta=1	0.57	0.49	0	1
Distance to township's bank branch (DIST)	km	18.54	22.32	1.61	96.60
Rice_income	000 Kyat	1670.22	1143.53	50.00	6620
Total_income	000 Kyat	2503.04	1426.84	120.00	13250
Credit per acre from MADB	000 Kyat	109.08	59.58	0.00	285.71
Total farm households (N)	number	413			

Table A2: Summary Statistics for farm households with landholding of >10 acres

Variable	Units	Mean	Std.Dev	Min	Max
Output(kg) (Y)	kg	30247.03	20814.91	564	129580
Output per acre	kg	1146.86	367.75	31	2382.60
Landholding size (LAND)	acre	22.45	13.27	10	70
Age of household head (AGE)	years	52	11	27	83
Gender of household head (GENDER)	male=1	1.05	0.21	1	2
At most primary education (EDU12)	yes=1	0.57	0.50	0	1
Secondary education (EDU3)	yes=1	0.27	0.44	0	1
High school/ higher education (EDU45)	yes=1	0.16	0.37	0	1
Experience of household head (EXP)	years	29	11	4	60
Household labour (HHLAB)	number	2.92	1.65	1	9
Dependency ratio (DEP)	ratio	0.48	0.24	0	0.9
Irrigation services (IRRI)	rank	0.90	0.29	0	1
Agricultural extension services (AES)	yes=1	0.58	0.49	0	1
Region (REGION)	Delta=1	0.86	0.35	0	1
Distance to township's bank branch (DIST)	km	214.20	12.90	2	97
Rice_income	000 Kyat	6344.00	4621.03	162	24750
Total_income	000 Kyat	7671.97	5480.57	855	38190
Credit per acre from MADB	000 Kyat	71.54	36.82	0	193.61
Total farm households (N)	number	221			

Table A3: Reduced form regressions for intervals of 0-20 acres and 5-15 acres

VARIABLES	Rice output (kg)		Rice output per planted acre (kg)		Rice income (000 Kyat)		Total income (000 Kyat)	
	0-20	5-15	0-20	5-15	0-20	5-15	0-20	5-15
Constant	583.51	-50495.98	737.87***	17.28	186.02	-7155.42	585.33**	-4301.86
	(1399.73)	(28030.83)	(194.99)	(1299.06)	(271.68)	(5504.69)	(285.36)	(5501.75)
Acres land holding >10	-726.85	-2042.65	-95.00	-167.37	-175.28	-263.78	616.06*	-613.10*
	(1759.02)	(1929.12)	(100.14)	(122.47)	(318.42)	(416.25)	(343.12)	(362.05)
Acres land	770.50	20081.99	77.49	384.17	154.12	2957.90	352.545***	2047.26
	(697.08)	(9749.16)	(64.58)	(441.70)	(125.87)	(1924.83)	(87.65)	(1882.26)
Acres land holding squared	110.26	-2211.96	-3.72	-44.69	20.47	-316.24	-11.86*	-200.52
	(94.14)	(1068.60)	(6.85)	(47.01)	(16.67)	(212.67)	(7.12)	(204.98)
Acres land holding cubed	-4.58	84.59	0.05	1.77	0-.78	11.98	0.23	7.77
	(3.29)	(37.02)	(0.20)	(1.58)	(0.59)	(7.48)	(0.15)	(7.07)
Observations	537	293	537	293	537	293	537	293
R-squared	0.48	0.33	0.01	0.03	0.51	0.28	0.46	0.26
F	27.05	46.42	1.78	2.11	26.80	28.46	29.89	35.68

Notes : 1) *, ** and *** correspond to statistical significance at 10%, 5% and 1% levels respectively. 2)Standard errors are presented by number in parentheses.

Table A4: Instrumental variable estimates with different sets of control variables (0-20 acres)

Variable	Rice Output (kg)	Output per acre (kg)	Rice Income (USD)	Rice Output (kg)	Output per acre (kg)	Rice income (USD)
Credit per acre	34.29	4.48	8.27	-5.90	1.03	8.73
	(82.34)	(4.63)	(14.54)	(65.86)	(3.27)	(13.76)
Control variables						
Land size polynomial[a]	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics [b]	No	No	No	Yes	Yes	Yes
Irrigation [c]	No	No	No	Yes	Yes	Yes
Regional charateristics [d]	No	No	No	Yes	Yes	Yes
Observations	537	537	537	537	537	537

Notes: ([a]) Cultivated land size polynomial: a third degree polynomial of cultivated land size (acres); ([b]) Farm and personal characteristics: Household head's age, gender, education levels, number of household labours, dependency ratio. ([c]) availability of extension services and Irrigation: access to very good/good irrigation. ([d]) Regional characteristics: Distance to the market and regional dummy variables for Sagaing (Dry Zone), Bago (Delta Region) and Ayeyarwady (Delta Region). Standard errors are presented by number in parentheses. *, ** and *** correspond to statistical significance at 10%, 5% and 1% levels respectively.

Table A5: Instrumental variable estimates with different sets of control variables (5-15 acres)

Variable	Rice Output (kg)	Output per acre (kg)	Rice Income (USD)	Rice Output (kg)	Output per acre (kg)	Rice income (USD)
Credit per acre	120.41	9.87	15.55	62.65	6.67	19.57
	(112.56)	(13.39)	(23.06)	(118.94)	(6.93)	(30.02)
Control variables						
Land size polynomial[a]	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics [b]	No	No	No	Yes	Yes	Yes
Irrigation [c]	No	No	No	Yes	Yes	Yes
Regional characteristics [d]	No	No	No	Yes	Yes	Yes
Observations	293	293	293	293	293	293

Notes: ([a]) Cultivated land size polynomial: a third degree polynomial of cultivated land size (acres); ([b]) Farm and personal characteristics: Household head's age, gender, education levels, number of household labours, dependency ratio. ([c]) availability of extension services and Irrigation: access to very good/good irrigation. ([d]) Regional characteristics: Distance to the market and regional dummy variables for Sagaing (Dry Zone), Bago (Delta Region) and Ayeyarwady (Delta Region). Standard errors are presented by number in parentheses. *, ** and *** correspond to statistical significance at 10%, 5% and 1% levels respectively.

Table A6: Instrumental variable estimates with different sets of control variables (0-20 acres) and (5-15) acres acres

Variable	Total Income (000 Kyat)			
	(0-20)	(5-15)	(0-20)	(5-15)
Credit per acre	26.47*	36.14*	22.29*	57.57*
	(14.14)	(22.19)	(21.80)	(35.71)
Control variables				
Land size polynomial[a]	Yes	Yes	Yes	Yes
Household characteristics [b]	No	No	Yes	Yes
Irrigation [c]	No	No	Yes	Yes
Regional characteristics [d]	No	No	Yes	Yes
Observations	537	537	293	293

Notes: ([a]) Cultivated land size polynomial: a third degree polynomial of cultivated land size (acres); ([b]) Farm and personal characteristics: Household head's age, gender, education levels, number of household labours, dependency ratio. ([c]) availability of extension services and Irrigation: access to very good/good irrigation. ([d]) Regional characteristics: Distance to the market and regional dummy variables for Sagaing (Dry Zone), Bago (Delta Region) and Ayeyarwady (Delta Region). Standard errors are presented by number in parentheses. *, ** and *** correspond to statistical significance at 10% 5% and 1% levels respectively.

Table A7: Instrumental variable estimates of the various specifications with covariates

Variable	Different interval of land size		
	±0.5 acre	±1 acre	±1.5 acre
(1)	(2)	(3)	(4)
Credit per acre	-135.33	-286.25	-431.82
	(636.61)	(484.24)	(1647.22)
Control variables			
Land size polynomial[a]	Yes	Yes	Yes
Household characteristics [b]	Yes	Yes	Yes
Irrigation [c]	Yes	Yes	Yes
Regional characteristics [d]	Yes	Yes	Yes
Observations	68	93	103

Notes: ([a]) Cultivated land size polynomial: a third degree polynomial of cultivated land size (acres); ([b]) Farm and personal characteristics: Household head's age, gender, farming experience, education level, household size, dependency ratio. ([c]) availability of extension services and Irrigation: access to very good/good irrigation. ([d]) Regional characteristics: Distance to the market and regional dummy variables for Sagaing (Dry Zone), Bago (Delta Region) and Ayeyarwady (Delta Region).
Standard errors are presented by number in parentheses. *, ** and *** correspond to statistical significance at 10%, 5% and 1% levels respectively.

Chapter 4

An analysis of the determinants of income diversification and income inequality in rural economy in Myanmar

4.1 Introduction

Rural households in many developing countries are increasingly diversifying their sources of income. In recent years, rural households have no longer engaged in the agricultural sector alone, and they instead combine a wide range of activities to construct a diversified livelihood portfolio (Ellis, 2000b). Through diversification, households can increase their aggregate income level from farming activities, off-farm wage employment, non-farming activities and remittances from family members who are working in urban areas and abroad. Diversifying incomes from both farm and non-farm activities has become a widespread strategy for reducing environmental risks, alleviating poverty, developing rural areas, and improving the living standards of rural households (Zhao and Barry, 2014).

Given the important role of income diversification, much of the literature has demonstrated the factors determining income diversification among rural households. Income diversification is mostly determined by 'seasonality, risk, labour markets, credit markets, asset strategies and coping farming activities' (Ellis, 2000a, p.299). For example, Adebayo et al. (2012) have examined the educational level of household head, farm size, membership of cooperatives and non-farm income that determine income diversification in Nigeria's Kaduna State. Similarly, a recent study by Agyeman et al. (2014) has found that the main factors relating to income diversification in Ghana are age, the gender of the head of household, educational level of household head, income per capita of household, and access to roads.

Income diversification, however, is associated with a higher risk of income failure for higher income households, and a lower risk of income failure for lower income households (Ellis, 2000b). Income diversification, therefore, can have either a positive or negative effect on the income of household. Barrett et al. (2001) showed a positive effect of income diversification on living standards of rural households in Africa. In a recent study, for example, Zhao and Barry (2014) have also found a positive impact of income diversification on lower income households in China. In contrast, Katchova (2005) investigated a negative impact of income diversification on households in the United States.

In addition, a number of studies have paid attention to the impact of non-farm income and its contribution to income inequality among households. However, the findings from these studies show different results for the effect of non-farm income on household income inequality. For example, empirical studies by Elbers and Lanjouw (2001), and Senadza (2011) found that increased income from non-farm sources may raise income inequality among rural households in Ecuador and Ghana respectively. In contrast, Adepoju and Oyewole (2014) argued that an increased income in rural households in Ghana from non-farm income activity can reduce inequality.

In the case of Myanmar, 75 per cent of people living in rural areas are engaged in the agriculture sector. Most rural farm households have become a focus of the diversification of agricultural activities for their income sources since the late 1980s. During the socialist period (between 1962 and 1988), Myanmar's economic policy heavily emphasised rice production (Soe and Fisher, 1990). Under this policy framework, the government took over all activities of production, distribution, transportation and exporting. However, market reforms in 1987 and 2003, removed the quota of compulsorily procured paddy, and released the restrictions on seven varieties of pulses and beans (Thein, 2004)

As a result of these reforms, farm households could freely decide to cultivate a variety of cash crops. Production of pulses and beans, therefore, has expanded greatly since the early 1990s. The reasons for the expansion in pulse production include an increased demand for pulses, the increased price of pulses, less demand for water, and especially less government regulation of exports of pulses while rice exports are still under government's control. Farmers, therefore, grow more commercial crops of pulses and beans in the summer season.

Although the rural economy has to some extent diversified, participation in crop diversification, off-farm activities and non-farm activities depends on rainfall and irrigated water, the condition of the soil, labour availability, distance to market, and access to credit. The degree of diversification is driven by regional specialization, as production of some crops is essentially dependent on soil quality and availability of water.

The literature on the determinants of income diversification and its effect on rural households in Myanmar is limited. Okamoto (2008) investigated the behaviour and welfare of rural households in Myanmar under the transition-period to a market economy. Her findings showed that farmers who concentrated on rice production had lower incomes than those who grow both rice and pulses. Kurosaki (2008) also investigated crop choices, farm income and political relations in Myanmar and found that there was a negative relationship between paddy acreage share and per-acre crop income. In the case of Myanmar, however, the previous literature has not paid attention to the factors determining income diversification from different sources of rural household incomes. Moreover, studies of livelihood strategies and their contribution to income inequality among farm households in Myanmar have received little attention in the literature. To fill this gap in the literature, this chapter contributes to the understanding of income diversification and its impact on rural households.

This study attempts to investigate specific patterns of rural income diversification and their effects on farm households in different rural areas in Myanmar. A better understanding of the link between income diversification and overall income inequality will guide rural households in the selected regions to increase their income in more efficient ways. The research questions that guide this paper are: 'What are the factors influencing income diversification in Myanmar's rural economy?', and 'Does income diversification contribute to income inequality among rural households?'. The remaining part of this chapter is organised as follows: Section 4.2 provides a brief background to Myanmar agriculture. Section 4.3 explains the patterns of diversification in rural areas in Myanmar. Section 4.4 discuss the literature on income diversification. Section 4.5 describes the data sources and variables, and Section 4.6 presents the patterns of diversification in the selected areas. Section 4.7 discusses the methodologies used in this study and reports the empirical results. Section 4.8 analyse the income inequality and discusses the results of the Gini coefficient. Section 4.9 presents the conclusion of findings.

4.2 Background to Myanmar agriculture

4.2.1 Myanmar's agricultural policies

Rice is Myanmar's most dominant crop as it is not only a staple food for the Myanmar people but also the main foreign exchange earner. During the socialist period (1962-1988), the government controlled all food production activities to ensure food security. Myanmar had a state monopoly over both domestic and international in agricultural products until the late 1990s. In 1963, the government began exercising greater controls over agriculture. It started specifying what crops should be grown in particular regions. Especially for rice production, it introduced a compulsory procurement scheme whereby farmers had to deliver a defined percentage of their produce to the government at a fixed procurement price by the government.

Farmers in Myanmar's main rice-growing areas had to deliver approximately 20 per cent of their gross output. However, the quota proportion was relatively lower in other rice-growing regions. Farmers who failed either to contribute the quota determined by the government or to cultivate the planned crops lost their land tillage rights for the next year. More strictly, the state owned all farm lands and prohibited farmers to transfer, sell or mortgage their land tillage rights to others. Under this framework, there was little incentive for farmers to invest in land productivity, which resulted in no significant improvement in the agriculture sector during the socialist period (Okamoto, 2008).

This changed after 1987, when the government started to move towards a market economy and began to lift trade restrictions on paddy, and seven varieties of pulses and beans, and maize. In 1988, the government reduced the quota of monsoon paddy that was compulsorily procured from farmers. According to the reform, farmers were now free to choose the cultivation of all crops and to sell their output in domestic markets. The government also lifted the restrictions on the private export of some agricultural crops such as black gram, green gram, maize and pigeon pea. However, rice exports remained under state control through the Association of Myanmar Agricultural Produce Trading (MAPT).

In 1992-1993, the government initiated the Summer Paddy Production (SPP) program with the expansion of land and a huge investment in irrigation projects in an attempt to promote rice production. The total sown acreage under summer paddy increased significantly from 0.8 million acres in 1992–1993 to 2 million acres in 1999–2000. Between 1988 and 1999, the Ministry of Agriculture and Irrigation completed 108 irrigation projects. According to the SPP program, farmers could freely grow commercial pulses and beans in the summer season unless those farmers were included in the planned areas.

In 2003, the government implemented a second phase of market reforms and finally abolished the procurement system (Okamoto, 2005). Due to less government regulation given in the production of pulses, these products have been freely sold in domestic markets and exported to international market[1]. In this connection, rural farm households had been given more incentives to diversify the cultivation of crops. Indeed, the production of pulses increased significantly after the agricultural reform in 1987.

Similar to the expansion of sown acreage for summer paddy, the cultivated land for pulses has been increased both in Lower Myanmar and in Upper Myanmar. More specifically, Sagaing, Magway and Mandalay regions in Upper Myanmar, and Yangon, Bago and Ayeyarwaddy regions in Lower Myanmar are the major regions for the production of pulses. The total sown acreage of pulse and paddy has increased by 310 per cent and 33 per cent production respectively between 1988-1989 and 2000-2001 (Okamoto, 2008). The expansion of sown acreage for pulse production and increased domestic and international demand for pulses were the main factors behind the increase in pulse production[2] .

Due to less demand for water and fewer expenses in production costs, pulses and beans are cultivated as a second crop in the dry season by using leftover moisture in the land after the cultivation of monsoon paddy. The increase in pulse production means that Myanmar is the second largest pulse producer in

[1]The export tax on pulse and bean products was 10% of export income for exporters between 1988 and 2010. This export tax was reduced to 2% in 2011.

[2]In 2014, the production of pulses was 5,947,363 metric tonnes with sown acreage of 4,534,000 hectares (Department of Agricultural Planning, 2014a)

the world market accounting for 7.3 per cent of world production in 2011-2013 (Joshi et al., 2004). Pulse and bean exports, therefore, have become an important source of foreign exchange earnings from agricultural produce in Myanmar. Among the 17 different varieties of pulses, black gram, green gram and pigeon pea contribute to over 80 per cent of the total pulse export value.

4.3 Patterns of diversification in rural areas in Myanmar

As mentioned in Chapter 1, 75 per cent of the Myanmar people living in rural areas are engaged in farming activities including crops, livestock, fishery or forestry. Apart from forestry, agricultural practices vary across the country based on seasons and agro-ecological zones. Generally, Myanmar has a tropical climate with monsoon, cold and hot seasons. The monsoon season occurs from May to October followed by the cold season from October to February, and the hot season from February to mid-May. Monsoon is the main season for rice cultivation all over the country. More specifically, monsoon paddy is grown from May to October, and summer paddy is grown from November to March.

In terms of agro-ecological zones, the Delta Region, the Central Dry Zone Region, the Coastal Region and the Hilly and Mountainous Region are categorised on the basis of topography, designation of land type[3], rainfall, sown crops and availability of irrigated water, and administrative state/regions. Due to the different agro-ecological zones and seasons, farming systems are highly diversified across the country. Figure 4.1 shows the major agro-ecological zones of Myanmar.

Among crops, rice paddy is cultivated almost everywhere in the country. Traditionally, monoculture rice cultivation or monsoon paddy was practised in the Delta region before 1991-1992. Since the introduction of the Summer Paddy Program (SPP) in 1992-1993, many farmers have begun double-cropping rice, namely, monsoon paddy and summer paddy, especially in the planned areas (Thein, 2004). Among the agro-ecological zones, the Delta Region is the heartland of rice production in Myanmar due to its rich alluvial soil, suitable

[3]Under the 2012 Farmland law, land type is designated as paddy land (*le*), *ya* land, *kaing* land, perennial plant land, *dhani* land, garden land, for growing vegetables and alluvial island. *Ya* land is mostly used for crops and mainly located in the central dry zone area.

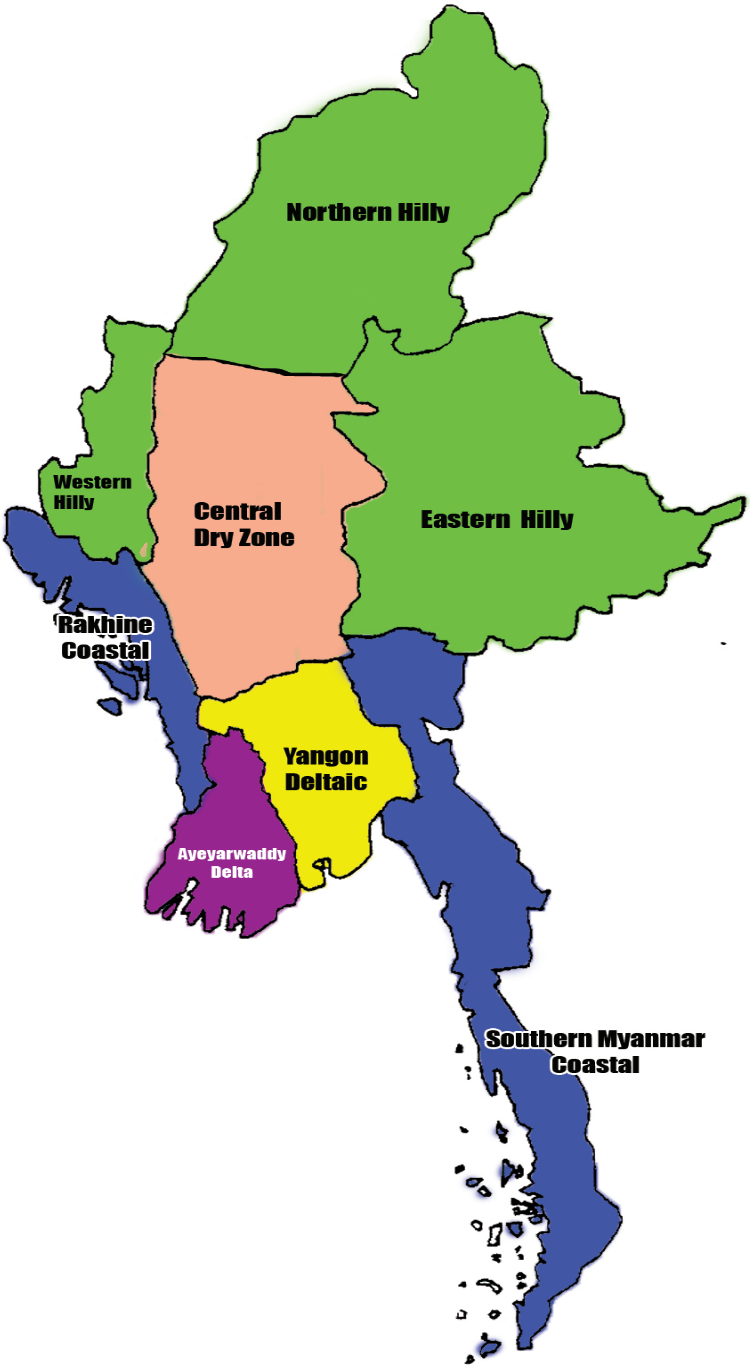
climatic conditions and availability of sufficient water. The delta region consists of three regions, namely, Ayeyarwaddy, Yangon and Bago. Among these three regions, the Ayeyarwaddy Region is known as 'Myanmar's rice bowl', contributing over 30 per cent of the national rice paddy output (Zaw et al., 2011).

Moreover, this region, which has more than 25 per cent of the total sown area under paddy cultivation, produces approximately 53 per cent of the total summer paddy output and 21 per cent of the total monsoon paddy, and highlights a higher degree of specialisation in rice production (Agricultural Extension Division, 2013). Although rice is the major crop, other non-rice crops, in particular, cereal crops, oilseed crops, industrial crops, pulses and beans are cultivated in this region. For example, Yangon and Bago in the Delta Region cultivate both paddy and different kinds of pulses and beans such as green gram (*pedisein*), black gram and pigeon pea (*pesingon*).

The Dry Zone contains lower part of Sagaing Region, western and central parts of Mandalay Region, and Magway Region. In the Dry Zone Region, most farmers intercrop pigeon pea with peanut or sesame or other pulses. The cropping pattern of paddy-paddy or paddy-pulse or paddy-pulse-paddy dominates in the irrigated areas. The cultivation of monsoon rice is under irrigation in these regions. However, a wide range of rain–fed crops such as oilseed, maize, sugarcane, various pulses and beans, and cotton are cultivated in the hot season. The Dry Zone Region produces groundnut, sesame, sunflower, black gram, green gram (*pedisein*), garden pea (*sadawpe*), pigeon pea (*pesingon*) and chick pea (*kalapea*), which make up the largest share of the total pulse and bean output in Myanmar (Robinson et al., 2008).

In the Hilly Area, most farmers grow sunflower, sugarcane, coffee, tea and a variety of horticulture products such as vegetables, fruits, onions, garlic and potatoes. Especially, farmers grow rice and wheat, which are their staple food, in the valley, and on the hills where terrace cultivation is practised. In the Coastal Region, farmers grow rice, sesame groundnut, sugar cane, and maize. This area mainly produces perennial crops such as oil palm, rubber and coconut.

Fig. 4.1 Agro-ecological zones of Myanmar



Source: Redrawn from Myanmar Rice Sector Development Strategy (Ministry of Agricultural and Irrigation, 2015)

4.4 Literature review

Traditionally, the income of rural households in developing countries primarily comes from traditional farming activities. Increased farm productivity might be used as a major tool for reducing rural poverty in many countries (Escobal, 2001). However, Oluwatayo (2009) has argued that farm households in many developing countries cannot earn sufficient income from farming source alone, and so must rely on other business activities for their livelihood. A number of empirical studies has shown rural households that use a diverse portfolio of activities to generate income. Most rural households are engaged in different activities to ensure their livelihood and improve their living standards (Ellis, 1998). A definition of income diversification among rural household has been described in various ways. Goletti and Rich (1998) have identified that income diversification of rural people can be from both agricultural activities (farm and off-farm) and non-agricultural activities.

More specifically, farmers can generate their income from farming activities, such as crop production, livestock and fishery. Off-farm income includes wages of labour on other farms, and income from other natural resource extraction, such as charcoal, firewood and wild plants. Non-farm income consists of income from non-agricultural sources, such as salary, non-farm self-employment[4] or non-farm household business (such as grocery shop, and workshop) and rental income received from land and other property such as farmland, tractors and draught animals, and remittances from family members who work either in urban areas or abroad (David et al., 2010). On the other hand, Mishra et al. (2010) have discussed the pattern of income diversification, which is categorized by pull factors and push factors in a number of studies in developing countries. Improved infrastructure and better market access, accumulation of income and wealth are identified as pull factors. Winters et al. (2009) and Barrett et al. (2001) also demonstrated that access to markets was one of the main factors leading to subsequently raise farm productivity and living standards of rural area in their studies.

Farm households frequently move to non-farm business activities to reduce the risk of environmental factors affecting farm productivity, and to avoid crop failure, and seasonal income variability. These factors are defined as push factors. Ellis (2000b) explained that the main reasons for diversification in agricultural activity were associated with spreading risk on the basis of mixed

[4]Non-farm rural self-employment is referred to as business income in some sources.

crops, different soil types, and changes in climate. 'The returns to production factors, market failures, and risk management are major reasons households participate in income diversification (Barrett et al., 2001; Davis, 2003).

Some rural households, therefore, take into account the opportunity of working in non-farm activities because of wage rates and security of employment. Most rural households might participate in multiple activities to reduce risk in response to market failure, or to raise their living standards (Barrett et al., 2001; Davis, 2003). Due to weather or other factors, some rural households try to reduce the variation in their income and move from crop production to non–farm activities, which are less likely to be affected by climate (Minot, 2006). Most rural households rely on other business activities to supplement their livelihood, as farming activities are typically seasonal (Kuwornu et al., 2014).

Moreover, the character of income diversification shows a relationship between people's assets and options that encourages alternative activities to generate the required income level of households. The nature of diversification includes the movement of resources from the cultivation of one crop to other crops; farming activities to non-farm activities; the transfer of resources to higher value agricultural products from the production of crops, livestock, and fishery; and the use of resources in a mix of different activities to achieve the optimum level of household income. The strategy of crop diversification has played an important role in improving household income in developing countries (Joshi et al., 2004). For example, in most South Asian countries, the diversity of crop production has been increasing since 1980. Pellegrini and Tasciotti (2014) found a positive relationship between crop diversification and income in rural households from eight developing countries, in particular, Albania, Indonesia, Malawi, Nepal, Nicaragua, Pakistan, Panama and Vietnam.

The share of income is mainly derived from a farm household's endowment such as ownership of land, and land size and quality, self-employment, non-farm labour income, human capital (such as the age of the household head, gender, educational level of household head and family size), draught animals (such as cows and buffaloes), and fixed capital (such as tractors and other machines) (Adebayo et al., 2012). In general, households with greater human capital endowments are more likely to participate in non-agricultural activities. If farm households have more and better quality land, sufficient available labour and fixed assets, they are most likely to focus on agricultural activities to generate their income. Farming activities, however, heavily depend on the availability of cultivated land acreage, provision of agricultural loans, access to agricultural extension services and infrastructure development.

Limited land, lack of irrigation facilities, and application of fertilizer are the main constraints to the potential development of the agricultural economy in most developing countries (Mehta, 2002). The expansion of non-farm activities, therefore, has become the alternative option to diversify household income and achieve the sustainable income for family survival in rural areas. A number of empirical studies emphasizes the determinants of income diversification and their impact on households. Adebayo et al. (2012) applied Tobit regression analysis to examine the determinants of income diversification of farm households in Kaduna State, Nigeria. Farm size, the household head's education, membership of cooperatives and income from non-farm activities were the significant factors among households in their findings.

Similarly, Agyeman et al. (2014) studied the determinants of income diversification of farm households in Ghana. They used the Simpson Index of Diversity (SID) to measure the degree of diversification. The age and education level of household heads, female household heads, number of extension visits, assets of production, and access to roads were the factors contributing to income diversification in their findings. Akaakohol and Aye (2014) also investigated how socioeconomic characteristics influenced decisions of farm households and the effect of diversification on household income in Nigeria. Consistent with the previous literature, the coefficients of age, education and credits had significant and positive effects on diversification. In their findings, a male household head played an important role in making decision as regards whether to participate in different activities. However, an unexpected finding was that household size had a negative effect on diversification in their study.

Moreover, the impact of different patterns of farm-level diversification on rural household income in China was studied by Zhao and Barry (2014). They showed that non-farm diversification and mixed diversification could generate more household income, especially for low-income rural households. Additionally, they found that low-income households were likely to participate in different business activities and increased their income if they had a larger portion of family workers. The assets of farm production were positively related to the income diversification of rural households. Consistent with Adebayo et al. (2012), Zhao and Barry also reported a significant and positive effect of education on rural income. In another study, by Sujithkumar (2007), the inverse Simpson Diversity Index (SID) was also used to measure livelihood diversification. The results showed that the higher income group had the highest degree of diversification. Moreover, richer households could generate a higher portion of their income from non-farm sources than poor households.

Some empirical studies give attention to the determinants of income diversification, while the other studies investigate the effect of non-farm income and its contribution to household income inequality. For example, Elbers and Lanjouw (2001) studied the impact of intersectoral transfer on the income distribution in Ecuador. They found evidence of a positive relationship between a rise in non-farm income and rural income inequality. Similarly, Adepoju and Oyewole (2014) found that income from non-farm activities was the major source of increasing income inequality compared to income from farming activities in Oyo state. In their study, livelihood diversification and its contribution to income inequality of rural households was analysed by applying the generalized entropy inequality indices.

To investigate the impact of income diversification on rural income inequality, Adams Jr (2002) used the standard decomposition of Gini coefficient. His estimates showed that income from non-farm sources could reduce inequality among households in rural areas in Egypt. Unexpectedly, income from agricultural activities contributed most to income inequality among the different income sources. Similar to Adams Jr (2002), Zhao and Barry (2014) also studied the distribution of non-farm income in rural China and confirmed that income from non-farm sources could help reduce income inequality among poor farm households. They also found that improved infrastructure and basic education level were crucial factors determining participation in non-farm activities. Moreover, Weldegebriel et al. (2015) demonstrated a negative impact of non-farm activities on income inequality in rural Ethiopia. In their findings, wealthier households had more incentive to diversify than poor households. The contribution of income from non-farm sources to total household income might be relatively low even if small farm holders were engaged in different business activities.

Although much of the literature shows the relationship between the determinants of diversification and rural household income, little is known about the effect of diversification on farm returns and its contribution to farm household income inequality in Myanmar. Okamoto et al. (2003) investigated the welfare of rural households under the transition to a market economy in selected areas in Myanmar, and found that farmers who concentrate on rice production had lower incomes than others. Kurosaki (2008) applied regression analysis to examine political control and its impacts on crop choice and farm income in Myanmar. Consistent with Okamoto et al. (2003), Kurosaki (2008) found that farmers might have low income if they are forced to grow paddy by the local administrator.

Neither Okamoto nor Kurosaki focused on the determinants of income diversification and income inequality among rural households in Myanmar. In an attempt to fill the gaps in the previous literature, the current study uses the inverse Herfindahl index to investigate the degree of income diversification, and the Gini decomposition coefficient to measure income equality in the selected regions in Myanmar.

4.5 Data source and variables

This study uses the primary field survey data collected in 2014 to analyse the determinants of income diversification and income inequality among rural farm households. The number of households totalled 634 farms across 30 villages in 6 townships. Specifically, 215 farm households, 212 farm households and 207 farm households were selected from Ayeyarwaddy, Bago and Sagaing respectively.

As mentioned in the previous section, this paper has two tasks. The first is to analyse the factors determining why farm households participate in farm activities and non-farm activities. Indeed, farm activities imply the production of mono-rice cropping, double-rice cropping, pulses and beans, other crops (sesame, maize, and corn), horticulture products (tomato, fruits, and vegetables), livestock (pigs, goats, ducks, and chicken) and fishery (fish and prawn). The second is to explore the impact of income from different sources on income inequality among rural farm households.

To analyse the first task, the variables of interest in this study are total agricultural land (both rice and non-rice crops), the demographic characteristics of households (such as household head's age and education), number of household labours, and number of dependent members. Moreover, the ownership of capital, in particular draught animals (cows and buffaloes) and tractors, are included to estimate their influence on the diversified activities. The other variables, such as access to agricultural extension services, the irrigation system, access to credit from both formal and informal sources, the distance from a village to a market, and geographical location, are also taken into account in the analysis.

For both tasks, the income sources of an individual household are divided into six categories: i) income from rice, ii) income from non-rice crops, iii) income from horticulture, iv) income from livestock, v) income from fishery, and vi) income from non-farm activities [5]. Total output including rice, non-rice crops is used to compute total income from rice and non-rice crops for each farm household. Income from non-farm activities is generated from the other sources, including trade, wages from non-farm sources, rental fees and remittances from household members living in urban areas and abroad. The patterns of diversification in the selected rural areas are briefly discussed in the next section.

4.6 The patterns of diversification in the selected areas

The distribution of income diversification activities by households in the selected regions is summarised in Table 4.1. All the selected 634 households are located in major rice-growing regions: 99 per cent and 30 per cent are engaged in monsoon paddy production and summer paddy production respectively. In particular, farm households in Ayeyarwaddy are mainly engaged in mono-rice production. However, Sagaing, which has the lowest number of households producing summer paddy, accounts for only 0.5 per cent of the total farm households among these regions. Due to insufficient irrigated water, most farmers in Sagaing lack motivation to grow summer paddy.

Farm households in Bago and Sagaing are increasingly diversifying their income by producing a variety of cash crops. Of the 212 farm households in Bago, 157 (approximately 70 per cent) grow a variety of pulses and beans. Similarly, of the 207 farm households in Sagaing, 141 (approximately 66 per cent) cultivate a variety of pulses and beans, and other crops. In Bago, the

[5] The income in this paper was actually revenues from the six different sources for each of sample farm household. There has been lack of precise estimate of household income due to the challenges in estimating farm costs.

chief crops are peanut, green gram (*pedisein*), black gram (*matpe*), white kidney bean (*pephyulay*) and pigeon pea (*pesingon*). In contrast, black gram (*matpe*), pigeon pea (*pesingon*), chick pea (*kalapea*), garden pea (*sadawpe*), lentil (*penilay*), wheat, peanut, sesame, corn, sugar cane and maize are the dominant crops in Sagaing.

Table 4.1 The distribution of income diversification activities by farm households

Region\Business activities	Ayeyarwaddy	Bago	Sagaing	Number of farm households
Monsoon rice	210 (33.1%)	212 (33.4%)	207 (32.7%)	629 (99.2%)
Summer rice	152 (24%)	31 (5%)	3 (0.5%)	186 (29.3%)
Non-rice crops	1 (0.2%)	157 (24.7%)	141 (22.2%)	299 (47.2%)
Horticulture products	39 (6.2%)	20 (3.2%)	1 (0.2%)	60 (9.5%)
Livestock	88 (13.9%)	84 (13.2%)	86 (13.6%)	258 (40.7%)
Fishery	6 (0.95%)	4 (0.63%)	0 (0%)	10 (1.6%)
Non-farm	18 (2.9%)	42 (6.6%)	35 (5.5%)	95 (15.0%)
Number of farm households	215	212	207	634

As shown in Table 4.1, approximately 10 per cent of farm households grow horticulture products such as tomatoes, other fruits and vegetables. Livestock production is an important income source, although paddy contributes most to total household income followed by pulses and beans. There is little difference in participation in livestock production across regions. Approximately 41 per cent of farm households in these three regions derive income from livestock.

However, nearly 2 per cent of 634 farm households are involved in fishery, indicating that this source is not a major contributor to diversification of farming income. Only a small portion of households participate in non-farm activities: 3 per cent, 7 per cent and 6 per cent of farm households in Ayeyarwaddy, Bago and Sagaing respectively. The farm households in the selected areas, therefore, are less engaged in non-farm activities for their livelihood compared to farming activities.

4.7 The analysis of determinants of income diversification

4.7.1 Methodology

Many empirical studies have focused mainly on estimating the share of farm incomes derived from different sources. Others have used non-farm income share in the total household income to identify the level of income diversification (Ersado, 2006). The share of income from different sources is mainly used to measure the degree of diversification (Barrett et al., 2001). In comparison, David et al. (2010) and Reardon et al. (1992) used the share of non-farm income to determine the level of income diversification.

A number of studies has used different indicators to estimate the determinants of income diversification. For example, Khatun et al. (2012) used the Simpson index in their study of West Bengal, India. Other studies, conducted by Ersado (2006), Sarah (2012) and Adebayo et al. (2012) used the inverse Herfindahl Index to investigate the factors determining the income diversification in Zimbabwe, Kenya and Nigeria respectively.

Of these indices, the inverse of the Herfindahl Index is commonly used to estimate the degree of industry concentration due to its consideration of the number of income sources and their weight, and the consistency of share of income (Ersado, 2006). This measurement is more appropriate than the other indices as, unlike them, it does not group farm households by income source category (Dimova and Sen, 2010) and Ellis (2000b). Most previous empirical research has used the diversification index following Hannah and Kay (1977) as follows:

$$D = [\sum_{j=1}^{n} S_{j=1}^{\alpha}]^{1/(1-\alpha)} \tag{4.1}$$

where D is the diversification index, S_j is the share of the j^{th} income source with respect to the total income (i.e., S_j=Y_j/Y, J=1,2,3,..,n), Y_j is total income from source j, $Y=\Sigma_{j=1}^{n}\ Y_j$ is total household income from all sources; j=1,2,3,...,n, and α presents the parameter of diversity, such as $\alpha \geq 0$ and $\alpha \neq 1$. The value of α= 0 shows the number of income sources that a household earn for their livelihood. However, a lower value of α suggests that a given household has only one source of income.

In general, the diversification index with the parameter α measures the weight of a number of income sources and the balance of the distribution of income shares. A larger value in the diversification index value indicates a higher number of different income sources and a greater emphasis on the distribution of income shares.

While the value of α approaches 1, the calculation of the index becomes $[-\ \Sigma\ S_i\ log\ S_i\ ]$ where log refers to the natural log. This index is known as the Entropy index. For the value of α=2, the index becomes the inverse of the Herfindahl Index as follows:

$$D = \frac{1}{\Sigma_{j=1}^{n} S_j^2} \tag{4.2}$$

To investigate the determinants of income diversification at the household level, this study uses the inverse of the Herfindahl Index to measure the degree of diversification by taking α=2. As discussed above, rural household income is generated from the six different sources (j=1,2,3,...,n,), in particular, income from rice sales, income from non-rice crops sales, income from horticulture, income from livestock, income from fishery, and income from non-farm activities. Following Ersado (2006), the Ordinary Least Squares (OLS) regression is applied in this paper.

4.7.2 Econometric model specification

The OLS specification of household income diversification is as follows:

$$\begin{aligned} D_i = \beta_0 + \beta_1 AGE_i + \beta_2 AGE_i^2 + \beta_3 EDU2_i + \beta_4 EDU3_i + \beta_5 HHLAB_i + \\ \beta_6 DEP_i + \beta_7 LAND_i + \beta_8 IRRI_i + \beta_9 AES_i + \beta_{10} ANIMALS_i + \\ \beta_{11} TRACTORS_i + \beta_{12} CREDIT_i + \beta_{13} DIST_i + \beta_{14} REGION_i + \mu_i \end{aligned} \tag{4.3}$$

where D is the dependent variable representing the diversification index, AGE is age of the household head, AGE^2 is squared age of household head, EDU2 is a dummy variable of the household head's education (1= at most secondary education level and 0 for otherwise), EDU3 is a dummy variable of the household head's education (1= high school (or) higher education level and 0 for otherwise), HHLAB is number of family members who are engaged in any business activities, and DEP is the dependency ratio. LAND is household's total agricultural land (including *le* land for paddy cultivation and *yar* land for non-rice crop cultivation) measured in acres.

The farm households were asked to self-asses water availability from both natural and irrigated sources such as creeks/rivers, dams and reservoirs, and private channels that is defined as 1= very good/good and 0=not good. Agricultural extension services (AES) is defined as a binary variable if a farm household receives services from different institutions for farming activities (=1) or otherwise (=0). The ownership of cows and buffaloes (ANIMALS) or/and tractors (TRACTOR) is also defined as a binary variable: if the household owns them (=1) or otherwise (=0).

Although MADB is the main provider of agricultural loans for rice and non-rice crops, the amount of credit is insufficient for production cost. Farm household, therefore, borrow money from other sources including formal financial sources, such as UNDP, Co-operatives and LIFT, and informal sources, such as private money lender, relatives and friends. If a household could receive credit from either MADB or any other sources, dummy variable of access to credit is defined as 1=yes and 0=no. The access to market (DIST) is defined as the distance from each village to a market in the nearest township measured in kilometres. The dummy variable for location (REGION) is identified as 1 if a farm household is located in the Delta Region; otherwise it is 0.

Table 4.2 presents the summary statistics of the explanatory variables used for the analysis.

Table 4.2 Summary statistics for the selected farm households

Variable	Unit	Mean	Std.Dev	Min	Max
Age of household head (AGE)	year	51.09	11.87	22	86
At most primary education (EDU1)	yes=1	0.62	0.49	0	1
Secondary education (EDU2)	yes=1	0.25	0.44	0	1
High school/higher education (EDU3)	yes=1	0.13	0.34	0	1
Household labours (HHLAB)	number	2.91	1.52	1	10
Dependency ratio (DEP)	ratio	0.45	0.23	0	0.9
Rice cultivated land (LAND)	acre	13.71	12.96	1	84
Non-rice crops cultivated land (YA)	acre	3.69	6.08	0	40
Total agricultural landholding (LAND)	acre	13.47	11.56	1	78
Irrigation service good/very good (IRRI)	yes=1	0.82	0.38	0	1
Agricultural extension services (AES)	yes=1	0.58	0.49	0	1
Draught animals (ANIMALS)	yes=1	0.63	0.48	0	1
Tractor (TRACTOR)	yes=1	0.35	0.48	0	1
Access to credit (CREDIT)	yes=1	0.92	0.27	0	1
Distance to market (DIST)	km	17.02	19.65	1.61	96.6
Region (REGION)	Delta=1	0.67	0.47	0	1
Rice_income	000 kyat	3299.41	3638.79	50	24750
Non-rice crops_income	000 kyat	631.25	1192.32	0	13440
Horticulture_income	000 kyat	147.94	1208.11	0	20000
Livestock_income	000 kyat	147.62	314.70	0	3150
Fishery_income	000 kyat	23.31	317.42	0	7000
Non-farm_income	000 kyat	203.24	885.46	0	10000
Herfindahl Index (D)	index	1.59	0.56	1	3.47
Number of observations	634				

Household heads are on average about 50 years of age, indicating that they are mostly in their active years. The average labours of each household is 3 persons, and the mean value of the dependency ratio is 0.45. The educational level of household heads is 0.62 on average at most primary, showing that most have completed primary school. The average cultivated land for paddy is 13.71 acres, while the average cultivated land for non-rice crops is 3.69 acres. Total agricultural land is the total landholding area both *le* and *yar* for each of the household. The average land size of agricultural land is 13.47 acres, and the maximum area is 78 acres.

Approximately 63 per cent of farm households own cows or/and buffaloes, while 35 per cent have tractors for the production of rice and non-rice crops. Nearly 60 per cent of farm households have access to agricultural extension services. The mean value of irrigation is 0.82 in this study showing that the response of the irrigation system is relatively good. Similarly, the mean value of access to credit is significantly high showing that most farm households are likely to have easy access to credit. The distance from a village to the nearest market is 17 km on average. Approximately 67 per cent of farm households are located in the Delta Region, while 33 per cent of households are located in the Dry Zone Region.

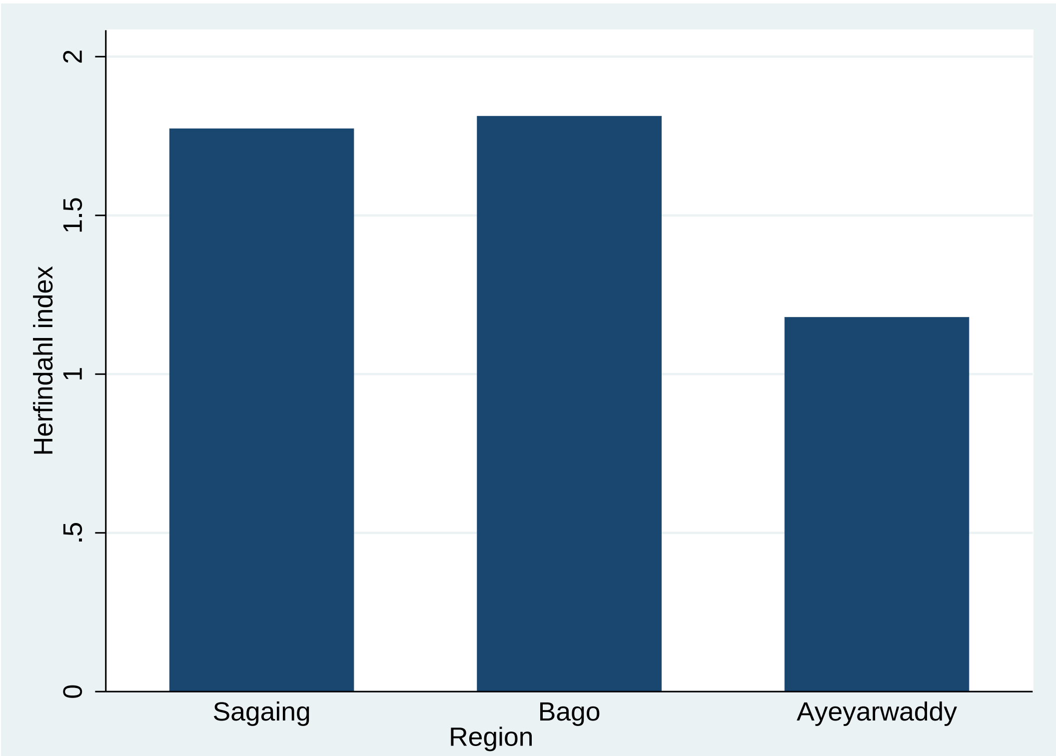
The summary of indexes is presented in Table 4.3. The value of the inverse Herfindahl Index (D) takes into account the variation in income shares to measure the degree of income diversification. A value of 1 suggests that households depend on a single source of income for their livelihood. Approximately 24 per cent of households are solely engaged in rice production, while 25 per cent and 32 percent of households have moderately diversified income. Nearly 19 per cent of households derive their income from multiple income sources, suggesting that those households with the most diversified income are likely to have higher value of D.

Table 4.3 Summary statistics of the inverse Herfindahl index

Index Value	Number of farmers	Mean	Std.Dev	Percentage
=1	151	1.00	0.00	23.82
>1 to ≤ 1.5	159	1.24	0.15	25.08
>1.5 to ≤ 2	201	1.79	0.15	31.70
>2 to ≤ 2.5	74	2.24	0.14	11.67
>2.5 to ≤3	41	2.72	0.16	6.47
>3	8	3.24	0.14	1.26
	634			100.00

The inverse of the Herfindahl Index across the three regions is illustrated in Figure 4.1.

Fig. 4.2 Inverse Herfindahl index by region



As expected, Ayeyarwaddy has the lowest diversification index compared to Bago and Sagaing. This is not surprising, as farm household-income in this region has been traditionally dominated by double-rice cropping followed by livestock income. The income diversification index in Bago is the highest, suggesting that farm households in Bago generate their income from various sources. On the other hand, the larger value of the Herfindahl Index confirms that farm households in Sagaing have a significantly higher level of diversification.

The share of income from different business activities is presented in Table 4.4. The proportion of income from rice production contributes the largest share of households compared to other business activities in each of the region. Ayeyarwaddy, which is the rice bowl of Myanmar, has the highest share of income from rice production followed by Bago and Sagaing, accounting for nearly 92 per cent, 65 per cent and 59 per cent respectively. For income from non-rice crops, Sagaing occupies the highest percentage followed by Bago. Most farm households, especially in Sagaing, grow non-rice crops or pulses and beans in summer season due to the lack of access to sufficient water. In contrast, income from non-rice crops contributes the lowest share of household's total income in Ayeyarwaddy.

Table 4.4 The share of income by different business activities

Income source	Ayeyarwaddy (%)	Bago (%)	Sagaing (%)
Rice	92.05	65.42	58.68
Non-rice crops	0.07	22.10	27.95
Horticulture	1.72	2.87	0.03
Livestock	4.20	3.61	7.89
Aquaculture	0.44	0.72	0.00
Non-farm	1.52	5.28	5.44

Among income sources, income from livestock is also one of the major sources for households in each of the region, nearly 8 per cent in Sgaing followed by 4 per cent in Ayeyarwaddy and Bago. There is no contribution of income from the source of aquaculture in Sagaing due to its geographical condition in the selected areas. Income from non-farm activities is seen as an important income source in Sagaing and Bago as its contribution of household's income is relatively larger among different activities.

4.7.3 Results

Results of the full sample

Table 4.5 presents the results of the regression analysis to estimate the determinants of income diversification. The household head usually decides whether or not to participate in different activities. The positive and significant result of age suggests that older household heads are likely to diversify their income sources. To study the effect of age on income diversification, the square of age is also taken into account in this analysis. Although the magnitude of squared age of household is relatively small, the coefficient is negatively and statistically significant at 1 per cent level. The results of age and squared age variables together explain the relationship between age and income diversification. Income diversification index increases in line with the age of household head participating in different activities. However, the negative value of age squared presents that old aged household heads become less interested in participating other business activities compared to household heads at younger age.

The secondary education (EDU2) has been found to have a positive and significant effect on income diversification at the 10 per cent level, indicating that education plays an important role in decisions to participate in both farm and non-farm activities. The household head who attained secondary education increases the likelihood that they will engage in their income generating activities. Similarly, the coefficient of household head with high school (or) higher education shows the positive and significant impact on the decision of participation in diversification. Higher income diversification is associated with better educated household heads. Household heads with better education are more likely to diversify their livelihood through participation in off-farm and non-farm business activities. The results of education impact on diversification are consistent with the findings of Adebayo et al. (2012), Khatun et al. (2012) and Akaakohol and Aye (2014).

Table 4.5 OLS estimation result of the determinants of income diversification

Variable	Coefficient	Std.Dev	t statistics
Constant	1.2800***	0.2878	4.45
Age of household head (AGE)	0.0253***	0.0096	2.63
Age squared of household head (AGE^2)	-0.0002***	0.0001	-2.58
Secondary Education (EDU2)	0.1063*	0.0606	1.75
High school/ higher Education (EDU3)	0.1776***	0.0663	2.68
Household Labour(HHLAB)	0.0179	0.0214	0.84
Dependency ratio (DEP)	-0.2536*	0.1366	-1.86
Total agricultural land (LAND)	-0.0067***	0.0025	-2.74
Irrigation services (IRRI)	-0.1114*	0.0671	-1.66
Agricultural extension services (AES)	-0.1071	0.0715	-1.50
Draught animals (ANIMALS)	0.2998***	0.0831	3.60
Tractors (TRACTORS)	0.0290	0.0661	0.44
Access to credit (1=yes)	-0.1525	0.1134	-1.35
Distance to market (DIST)	-0.0022	0.0023	-0.92
Region (REGION)	-0.1229	0.1466	-0.84
Number of observation (N)	634		
R^2	0.203		

Note:***, ** and * denotes the significance level at 1%, 5% and 10% respectively. Standard errors are shown in parentheses.

In general, household labour is also an important factor influencing income diversification. A household is more likely to participate in farming and non-farming activities due to the availability of the number of household labours. However, there is little evidence of its impact on diversification as the coefficient of HHLAB is not statistically significant in this case.

The coefficient of dependency ratio (DEP) is negatively significant at the 10 per cent level as expected. An increase in the dependency ratio reflects a higher portion of dependants who are unable to contribute to income diversification. Households with larger number of dependants have less diversified income than households with few number of dependent members.

The size of total agricultural landholding size (LAND) appeared to be the major factor affecting income diversification. The coefficient of agricultural land was negative and significant at 1 per cent level. The income diversification decreased with increase in total agricultural landholding size as farm households with larger size of agricultural land are much interested in growing more number of crops to increase their income compared to those with smaller land size. Total agricultural land strongly confirms that one acre increase in land size will reduce the level of participation in other activities by 0.007.

For farm households, better access to irrigation and extension services can generally help increase farm productivity and discourage farm households from participating in other business activities. The effect of irrigation (IRRI) on the level of income diversification is negatively and statistically significant at 10 per cent level. The result explains that farm households are likely to specialize in crop production rather than participation in other business activities if they can get better access to irrigation. The coefficient of access to agricultural extension services (AES) shows little impact on income diversification.

Ownership of working capital, including draught animals and/ or tractors plays an important role in influencing farm production. The ownership of draught animals (ANIMALS) has a positive and statistically significant effect on the level of income diversification at the 1 per cent level. Farm households with working capital have more diversified income sources and are probably more involved in other crop cultivation and non-farm business activities. This result is contrary to Sarah (2012), who found a negative relationship between access to animal ploughs and income diversification in Kenya. There is no evidence of impact of tractor ownership (TRACTOR) on income diversification as its coefficient is not statistically significant.

To analyse the response of farm households on access to credit, the variable of access to credit captures the relationship between access to credit and income diversification. Households with access to credit are more likely to have capital to invest in on-farm and off-farm activities, which can generate income for farm households. However, the coefficient of access to credit is not statistically significant showing that there is little impact of credit on diversification for sampled households in this study.

The distance from a village to market nearby a township is also an important determinant of rural income diversification. Farm households with easy access to markets are more likely to sell their products in markets and participate in other non-farm activities in nearby townships or other urban areas. Demissie and Legesse (2013), Khatun et al. (2012), and Asmah (2011) found a negative relationship between distance to market and participation in off-farm and non-farm activities. The coefficient of distance (DIST) is negative but not significant. This result, therefore, would not be able to highlight the impact of distance to market on the diversification in the selected regions.

Similarly, the coefficient of the dummy variable for regions is also not statistically significant, suggesting that there is little influence of region on the level of income diversification in this study.

As illustrated in Figure 4.1, the Herfindahl index for Sagaing is similar to that for Bago, but higher than that for Ayeyarwaddy. The insignificant regional effect indicates that income diversification among regions is likely due to other factors. This study, therefore, investigates the factors that are more important in explaining income diversification for each of the region in the next section.

Summary results of Ayeyarwaddy, Bago and Sagaing

Table 4.6 summarises the OLS estimation result of the determinants of income diversification for each region. The coefficient for the age the household head is significantly and positively related to income diversification in Bago and Sagaing. The coefficient of squared age of the household head has a significant and negative effect on diversification. These results imply that older household heads become less likely to participate in income diversifying activities compared to younger household heads. However, the coefficients of Ayeyarwaddy are not significant.

In Table 4.5, the results of education in the full sample show the important role of both secondary education and higher education on income diversification Contrary to the main results, the coefficients for secondary education or higher education are not statistically significant in each of the regions.

The variable of HHLAB represents the number of working family members. A household with more family labours is more likely to participate in farming and non-farm activities due to the availability of labour. The result of Ayeyarwaddy confirms the positive and significant effect of the available family workers on income diversification. However, the results show an insignificant impact of household labours on diversification in Bago and Sagaing.

The coefficient of dependency ratio (DEP) should be negative and significant as the increase in the dependency ratio reflects a higher portion of dependents who are unable to contribute to income diversification. Households with larger numbers of dependents have less diversification than households without any dependent members. The coefficients for each of the regions, however, do not show the effect of dependency ration on diversification in this study.

The total agricultural land (LAND) has a significant and negative effect on diversification at the 5 per cent level in Ayeyarwaddy and Bago, but insignificant effect in Sagaing. The results suggest that farm households with having more land available for rice and non-rice crop production have less motivation to participate in other business activities.

The coefficient of access to agricultural extension services has an insignificant effect on income diversification in each of the region. Similarly, the coefficient of irrigation (IRRI) has little influence on income diversification in Ayearwaddy and Sagaing. However, the coefficient of access to irrigation positively and significantly associated with income diversification in Bago. Approximately 86 per cent of 212 farm households participate in different business activities although the irrigation system is relatively good in Bago.

With regard to the ownership of working capital including draft animals and tractors, the results are different between Ayeyarwaddy and Bago. The coefficients of ownership for both draft animals and tractors in Ayeyarwaddy are negative and significant at 10 per cent level. The possible explanation for this is because it is the most rice growing region. Nearly 70 per cent of 215 farm households are mainly engaged in double-rice cropping, compared to Bago and Sagaing. The coefficient of ownership of assets suggest that households with owing both draft animals and tractors are likely to use land more efficiency to improve rice productivity. The degree of income diversification will decrease by 0.08 and 0.05 if a farm household owns draught animals and tractors respectively.

Table 4.6 OLS estimation results of the determinants of income diversification for Ayeyarwaddy, Bago and Sagaing

Variable	Ayeyarwaddy	Bago	Sagaing
Constant	1.647***	1.219**	0.200
	(0.496)	(0.335)	(0.382)
Age of household head (AGE)	0.001	0.021*	0.040**
	(0.012)	(0.011)	(0.017)
Squared age of household head (AGE^2)	-0.00003	-0.0003**	-0.0003**
	(0.0001)	(0.0001)	(0.0002)
Secondary education (EDU3)	0.037	0.112	-0.128
	(0.028)	(0.087)	(0.109)
High school/ Higher education(EDU45)	-0.042	0.155	-0.044
	(0.054)	(0.106)	(0.082)
Household Labour (HHLAB)	0.047**	-0.002	-0.001
	(0.019)	(0.032)	(0.032)
Dependency ratio(DEP)	0.035	-0.302	0.136
	(0.066)	(0.211)	(0.133)
Total agricultural land (LAND)	-0.002**	-0.011**	-0.006
	(0.001)	(0.005)	(0.005)
Irrigation services (IRRI)	-0.072	0.276***	-0.090
	(0.156)	(0.085)	(0.058)
Agricultural extension services (AES)	-0.037	0.040	-0.222
	(0.048)	(0.063)	(0.177)
Draught animals (ANIMALS)	-0.078*	0.149***	0.370***
	(0.041)	(0.054)	(0.132)
Tractors (TRACTORS)	-0.053*	0.186***	0.026
	(0.030)	(0.069)	(0.130)
Access to credit (CREDIT)	-0.307	0.202**	0.156
	(0.372)	(0.082)	(0.109)
Distance to market (DIST)	-0.004**	-0.021*	0.003
	(0.002)	(0.012)	(0.003)
Number of observation (N)	215	212	207
R^2	0.15	0.25	0.22

Note:***, ** and * denotes the significance level at 1%, 5% and 10% respectively. Standard errors are shown in parentheses.

In contrast, the results for Bago region is significantly different from that of Ayeyarwaddy. The ownership of draft animals and tractor is positively and significantly related to income diversification in Bago. Nearly 35 per cent and 40 per cent of households owned tractors and draft animals respectively. Those households are likely to use production assets in other business activities compare to other households who do not have the property of assets that leads farm households to diversify their incomes. Similar to Bago, the ownership of draft animal could encourage farm households to diverse other business activities in Sagaing. The coefficient of tractor, however, is not statistically significant.

The significant coefficient of access to credit in Bago shows a positive relationship between availability of credit and household's income-diversifying activities. Households have more motivation to start other business if they can borrow more credit from different sources. However, household's participation in other business activities does not strongly rely on the access to credit in Ayeyarwaddy and Sagaing as their coefficients are not statistically significant.

The effect of distance to market on income diversification differs between regions. In the Delta region (Ayeyarwaddy and Bago), the negative effect of distance to market on the diversification level is found at the 5 per cent and 10 per cent significance level respectively. The result suggests that farm households far from markets are less likely to participate in income-diversifying activities due to higher transaction costs. However, the result is not significant in the Dry region (Sagaing).

Due to the geographical region, the determinants of diversification vary among the regions. Total agricultural land and the ownership of draft animals are main determinants in the participation of diversification. The age of household heads and distance to market are important factors determining income diversification in Ayeyarwaddy and Bago regions.

4.8 The analysis of income inequality

4.8.1 Methodology

A number of empirical studies, for example those conducted by Nugent and Walther (1982) and Pyatt et al. (1980), have used various methods to identify the contribution of different sources of income to total income inequality, especially in developing countries. There are several measures of inequality, such as 'Theil's entropy index T, Theil's second measure L, the coefficient of variation and the Gini coefficient' (Adams, 1993, p.1188). It is noteworthy that a rule of the decomposition procedure requires no restrictions for non-overlapping groups of income source when inequality can be allocated over the regions. However, the two Theil measures are not appropriate for decomposition when household incomes from different sources overlap.

On the other hand, Shorrocks (1982) demonstrated that the results of the decomposition of inequality rely on the rule of the decomposition procedure. He showed that there were many ways to measure income inequality by allocating the components of total income if there is no restrictive rule. The two remaining measures, therefore, are more appropriate for the decomposition analysis because many households in developing countries utilise different business activities for their income (Adams, 1993).

The decomposition of the Gini coefficient measures the contribution of an income source to overall income inequality, and whether each particular income source increases or decreases income inequality. It is the most widely used measure of the contribution of income sources to overall income, distribution of consumption and other purposes (López-Feldman et al., 2006). Adams Jr (2002) demonstrated how the decomposition of the Gini coefficient can identify how much of each income source contributes to overall inequality, and whether this inequality increases or decreases overall income inequality.

Following Lerman and Yitzhaki (1985) and Shorrocks (1982), the Gini coefficient for total income can be represented by decomposing the total household income as

$$G = \Sigma_{k=1}^{K} R_k G_k S_k \tag{4.4}$$

The study conducted by Stark et al. (1986) found that a relationship between three terms in Equation (4.4) explained the influence of any income source on overall income inequality depending on the importance of that component of income source relative to total income (S_k), the distribution of income from source k (G_k) and the correlation between the income source and the distribution of total household income (Rk).

A larger share of total household income from an income source is likely to have a larger impact on overall inequality. However, an equal distribution of each income source (G_k=0) has no influence on inequality, even if the share of the particular income source is large. On the other hand, larger values of both S_k and G_k indicate that the contribution of an income source contributes to increasing or decreasing overall income inequality. A positive and large value of R_k implies an unequal distribution of income source and its contribution to income inequality.

Adams (1993) defined the relative concentration coefficient of income source k in the total household inequality as

$$g_k = R_k \frac{G_k}{G} \tag{4.5}$$

The contribution of income source to total inequality depends on whether the value of relative concentration coefficient (g_k) is greater than or less than unity. If the value of g_k is greater than 1 (g_k>1), the income source of k is defined as increasing inequality. In contrast, if the value of g_k is less than 1 (g_k<1), the income source of k is defined as decreasing inequality.

4.8.2 Results of decomposition of the Gini coefficient

In this study, the decomposition of the Gini coefficient is used to examine the contribution of income from each of the six sources (rice, other crops, horticulture, livestock, fishery and non-farm) to overall income inequality among farm households. Due to their geographical locations, farm households are not likely to be involved in all of these six income sources. For example, most farm households in the Ayeyarwaddy region were not engaged in other crop production, while farm households in Sagaing did not participate in fishing. However, these income sources have different effects on income inequality. Therefore, incomes from all sources are taken into account for the analysis of the Gini coefficient.

Table 4.7 presents income per capita and income share of total income. Most farm households derive their income from rice production, which accounts for about 72 per cent of total household income. Production of crops is the next most important source, followed by livestock, contributing about 17 per cent and 5 percent respectively to total household income. However, the contribution of incomes from horticulture and fishery to total income is relatively very low in this study. Non-farm income is a less important source in this study, accounting for 4 per cent of total income.

Table 4.7 Income per capita and income share of total income

Income source	Mean income per capita (thousand kyat)	Mean share of total income (%)
Rice	682.555	72.25
Non-rice crops	127.140	16.54
Horticulture	26.171	1.55
Livestock	28.856	5.21
Fishery	4.485	0.39
Non-farm	36.708	4.06

Tables 4.8, 4.9, and 4.10 show the results of the decomposition of income inequality for the Ayeyarwaddy, Bago, and Saging regions respectively. As these are Myanmar's major rice growing regions, the share of rice income is expected to be relatively high. However, the contribution of rice production to income inequality is less equally distributed among these regions. The contribution of rice income on income inequality is fairly distributed in the Ayeyarwaddy as the value of the concentration ratio is around 1 (g_k=1.028) (Table 4.8, column 6).

In Bago, the value of the concentration coefficient g_k reveals that income from rice production represents an inequality-decreasing source of income because its relative concentration coefficient is less than 1 (g_k=0.960) (Table 4.9, column 6). However, the value of the coefficient of rice in Sagaing is larger than 1 (g_k=1.130) (Table 4.10, column 6), which implies that the contribution of rice income to income inequality is relatively unequal in Sagaing. Increasing inequality of rice income source might be associated with the varieties of seed and selling price of rice among farm households in this region.

As previously mentioned, Lanjouw et al. (2013) and Mishra et al. (2009) have demonstrated how income from non-farm activities plays a significant role in reducing income inequality among rural households. Contrary to their findings, this study argues that the contribution of income from non-farm activities is the second major source of income inequality with the contribution of 1.8 per cent in Ayeyarwaddy (Table 4.8, column 7), 6.2 per cent in Bago (Table 4.9, column 7) and 5.6 per cent in Sagaing (Table 4.10, column 7). However, the result is consistent with Adger (1999) and Senadza (2011) who

Table 4.8 Inequality decomposition by income sources in the Ayeyarwaddy Region

Income source	Share in total income	Gini coefficient	Gini correlation with total income	Absolute contribution to overall inequality	Relative concentration coefficient	percentage contribution to overall inequality
	(S_k)	(G_k)	(R_k)	(G_k)	(g_k)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Rice	0.939	0.457	0.989	0.424	1.028	96.50
Non-rice crops	0.000	0.995	-0.869	0.000	-1.966	0.00
Horticulture	0.014	0.934	0.355	0.005	0.754	1.00
Livestock	0.028	0.809	0.172	0.004	0.316	0.90
Fishery	0.002	0.981	-0.399	-0.001	-0.890	-0.20
Non-farm	0.016	0.965	0.494	0.008	1.083	1.80
Total	1.000	0.440		0.440		100.00

Note: Estimation of the Gini coefficient is based on per capita income for farm households.

found that non-farm income has less impact on income equality.

It is interesting to note that income equality is mainly explained by livestock income, i.e. 0.9 per cent in Ayeyarwaddy (Table 4.8, column 7), 0.7 per cent in Bago (Table 4.9, column 7) and 0.8 per cent in Sagaing (Table 4.10, column 7). In addition, the concentration coefficient of income from livestock (g_k) is smaller than 1, accounting for 0.32, 0.26 and 0.14 in Ayeyarwaddy, Bago and Sagaing respectively (see column 6 of Tables 4.8, 4.9, and 4.10). These results strongly confirm that livestock income is a major source of reducing income inequality among farm households.

Production of non-rice crops plays an important role in income diversification in Bago and Sagaing. As mentioned earlier, farm households in these two regions practise the rice-crop cultivation pattern, whereas most farmers in Ayeyarwaddy cultivate the rice-rice cropping pattern. In this study, about 70 per cent of farm households in Bago and Sagaing are engaged in the production of pulses and beans and a variety of other non-rice crops.

The concentration coefficient of income from non-rice crops (g_k) is relatively smaller than 1 in both regions, i.e. 0.93 in Bago (Table 4.9, column 6) and 0.84

Table 4.9 Inequality decomposition by income sources in the Bago Region

Income source	Share in total income	Gini coefficient	Gini correlation with total income	Absolute contribution to overall inequality	Relative concentration coefficient	percentage contribution to overall inequality
	(S_k)	(G_k)	(R_k)	(G_k)	(g_k)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Rice	0.635	0.454	0.918	0.265	0.960	61.00
Non-rice crops	0.213	0.597	0.675	0.086	0.929	19.70
Horticulture	0.060	0.967	0.814	0.047	1.814	10.80
Livestock	0.025	0.805	0.139	0.003	0.258	0.70
Fishery	0.011	0.989	0.628	0.007	1.431	1.60
Non-farm	0.056	0.902	0.527	0.027	1.095	6.20
Total	1.000	0.434		0.434		100.00

Note: Estimation of the Gini coefficient is based on per capita income for farm households.

in Sagaing (Table 4.10, column 6). Income from non-rice crops represents an inequality-decreasing source of income, because the percentage contribution to overall inequality (19.8 in Bago and 21.8 in Sagaing) (column 7 of Tables 4.9 and 4.10) is lower than that share of total income (S_k =21.3 in Bago and S_k =25.9 in Sagaing)(column 1 of Tables 4.9 and 4.10).

More importantly, farmers in Sagaing are likely to take advantage of crop cultivation due to less demand for irrigated water. In addition, a higher price for pulses and beans provides more incentive for farm households to derive their income from non-rice crops.

The effect of fishery income shows different results in Ayeyarwaddy and Bago. The contribution of fishery income to income inequality is found to be relatively unequal (g_k= 1.43) in Bago. In contrast, the rank correlation between fishery income source and total income (R_k=−0.40) shows that there is a significant decline in importance of fishery income relative to total household income in Ayeyarwaddy. The effect of fishery income is not analysed in the Sagaing region, as no farm households are involved in fish production due to the nature of geographical location.

Overall, there is little difference in the value of Gini coefficient (G_k) among three regions. However, the Gini coefficient (G_k) is the lowest in Bago with

Table 4.10 Inequality decomposition by income sources in the Sagaing Region

Income source	Share in total income (S_k)	Gini coefficient (G_k)	Gini correlation with total income (R_k)	Absolute contribution to overall inequality (G_k)	Relative concentration coefficient (g_k)	percentage contribution to overall inequality
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Rice	0.636	0.576	0.892	0.327	1.130	71.80
Non-rice crops	0.259	0.656	0.585	0.099	0.844	21.80
Horticulture	0.000	0.995	0.175	0.000	0.383	0.00
Livestock	0.050	0.756	0.086	0.003	0.143	0.80
Non-farm	0.055	0.922	0.500	0.025	1.013	5.60
Total	1.000	0.455		0.455		100.00

Note: Estimation of the Gini coefficient is based on per capita income for farm households.

a value of 0.43. This implies that the equal distribution of income is due to inequality-decreasing sources of income from both rice and non-rice crops in Bago.

4.9 Conclusion

In developing counties, including Myanmar, most rural households seek to diversify their sources of income to increase their earnings. Since the introduction of agricultural reforms in 1987 and 2003, there has been a remarkable increase in diversification in Myanmar's rural areas. The purpose of this study has been to highlight the factors influencing income diversification in rural areas in Myanmar. This paper has also examined the impact of six income sources on rural income inequality. Three major rice growing regions, namely, Ayeyarwaddy, Bago and Saging were selected for analysing due to their different agro-ecological environments.

The inverse of the Herfindahl index is applied to investigate overall diversification. Based on the ordinary least regression (OLS) results, the educational level of the household head is found to have a positive and significant influence on the decision to undertake income diversifying activities, which implies that more educated farm households are likely to diversify their income-earning activities that can improve their income. Households with more dependants are found to have a lower level of participation in other business activities. The more the dependants in a family, the less participation in other business activities. Also, households with large farm areas have a better chance to increase their production and income from rice and non-rice crops compared to those who have smaller size of agricultural land.

Another important determinant is the ownership of working capital. Farmers who raised draught animals have a greater working capital, and affords to cultivate other non-rice crops, such as pulses, beans and maize. In general, better access to irrigation can encourage households to specialize on rice, non-rice crop, horticulture production. However, in the Delta Region, rain in monsoon season provides enough rain to grow rice successfully. Farmers in the Delta area, therefore, do not participate much in other business activities. The negatively significant result confirms the reason that farmers are less likely to participate in other non-rice business activities. In contrast, farmers in Sagaing Region get less rain and lack of good irrigation facilities. They produce non-rice crop, raise livestocks, and participate in non-farm activities to raise their household income.

Based on the results of income diversification for each region, total agricultural land available for rice and non-rice crops, ownership of draft animals, and better access to irrigation are important factors for a household's decision to participate in both farm and non-farm activities. However, factors affecting income diversification vary across the region.

It is surprising to find that travel distance from a village to the market in the nearest township is not a factor influencing a household's decision as regards whether or not to participate in the income diversifying activities in the full sample. However, there is a negative impact of distance to the nearest market in Ayeyarwaddy and Bago, where there is a positive effect in Sagaing. Most farm households in Sagaing are engaged in rice-crop production and other activities although their villages are quite distant from township markets. Unfortunately, the result of Sagaing is not statistically significant. A better explanation is that farm households in Ayeyarwaddy and Bago are less likely to participate in income-diversifying activities if their villages far from markets.

Overall, in the three regions, income inequality is mainly explained by rice income source. However, the contribution of rice income to inequality of earnings differs between the regions. Income from rice contributes decreasingly to income inequality in Bago, but it is a factor explaining increasing income-inequality in Sagaing.

Non-rice crops are the second-most important factor explaining income inequality. In Ayeyarwaddy, farmers can grow rice two times per year. Therefore, non-rice crops are less important in explaining income inequality there, but it is a factor explaining the increasing income inequality in Bago and Sagaing.

It is interesting to note that income from livestock consistently increases income equality of the six sources of rural income among farm households. Farm households can generate higher income through diversifying their activities in livestock in three regions. This finding suggests a need to promote better access to livestock in villages by providing farmers with greater credits.

This study indicates that there is a high correlation between non-farm income and income inequality in all regions. However, the results cannot provide the confirmation of the causality effect of non-farm activities in these regions.

There are many reasons for rural households to diversify their income. Based on the findings in this study, larger size of agricultural land, ownership or either draft animals or tractors, and better irrigation in rural areas help improve diversifying crop cultivation. Although the effect of the distance to market on income diversification is not well confirmed in this study, access to better transport is one of the important determinants in relations to greater education to farmers, better irrigation and agricultural extension services, and opportunities for both farm and non-farm income activities.

There are, however, some limitations in this chapter that should be taken into account in further research. Although crop income helps reduce income inequality in Bago and Sagaing, only gross income from both rice and other crop is included in this study. The cost and benefit analysis, therefore, should be conducted to estimate the net income from both stated income sources. By doing this, the net return from both income sources can clearly provide a better understanding of why farmers are more likely to participate in rice and other crops, especially in Bago and Sagaing. In addition, a further research needs to estimate labour wages from farm activities in the Gini decomposition analysis and to investigate the impact of this sources of earning on income inequality in Myanmar's rural areas.

Chapter 5

Conclusion

This thesis has described the background and current situation concerning the Government of Myanmar policies that affect rice production in the country. This study has summarised the existing literature on Myanmar rice production and rural income inequality, and identified gaps in our knowledge. The study has also analysed the credit policy of the Myanmar Agricultural Development Bank (MADB) and how it has affected rice production, rice productivity and rice income. The thesis has examined rice production and its implications for income inequality in Myanmar's rural areas. This thesis provided some policy recommendations to increase Myanmar's rice production and improve rural income equality, drawing upon the research findings and with a particular reference to the experience of another major rice-producing country that shares many features in common with Myanmar: Vietnam.

Successive governments in Myanmar have sought to develop the country's agriculture sector, with a particular focus on increasing rice production. In 1987, the government implemented the first agricultural reform by introducing advanced technology, reducing the amount of quota and removing the restrictions on the export of some agricultural crops. In 2003, the government launched another reform, the so-called 'second agricultural reform', removing the procurement system and liberalizing both domestic and export markets for agricultural products. The government also implemented the other programs to boost rice production including the provision of extension services, agricultural loans and the expansion of irrigation. Due to the successive reforms and programs, there has been a significant increase in rice, pulse and beans production.

In 2012, the civilian government enacted the Farmland Law to fulfil the objective of securing access to land for rural development. Under this policy, farmers have more freedom to choose the appropriate crops to sell or transfer, or they can mortgage or rent their land use rights to other people. Although not enough time has passed since the introduction of Myanmar's land reforms in 2012 to assess that effect on rice production, it is expected to deliver the same outcomes. Despite these efforts, Myanmar has not managed to develop its rice production to the same extent as other countries in the region. Most farms still use low-quality and low-quantity agricultural inputs, especially fertilizer and seed that deliver low yields, which results in lower income for farmers.

There have been several studies on rice production and efficiency in Myanmar. Although there were some differences in their findings, in aggregate, these studies found the positive effect of average years in school of household members who work in farming activities and agricultural extension services on rice production efficiency. However, the previous literature has not addressed certain important factors including landholding sizes with a number of plots, the distance from a village to a market nearby a township, the impact of credit policy on rice production and rural income inequality in Myanmar, a deficiency which this thesis has sought to fill. More importantly, this study gives attention to the endogenity problems for credit and agricultural extension services, and uses the fitting endogeneous stochastic frontier models with township fixed-effects to handle those problems.

The study's key findings suggest that larger farms with better irrigation systems, and those with access to agricultural extension services and more credit, are more efficient. Well-educated farmers with holdings of large farm sizes are more likely to increase their productivity and output than those who only have a primary school education. With regard to the effect of distance to market on rice production, the longer distance to a market nearby a township has a negative effect on production efficiency. Although there has been an increase in rice production, rice yield in Myanmar is relatively low compared to Vietnam, which has similar sown acreage and harvested areas to Myanmar. The performance of Vietnamese's rice production suggests that application of better quality seeds, effective use of fertilizers, irrigation facilities, and investment in research and development are important factors to improve Myanmar's rice sector.

The analysis of the second essay shows the importance of access to agricultural credit on farmers to improve their productivity by enabling them to improve the quality and volume of their inputs. Under the credit policy of the MADB, it provides only a limited amount of credit per acre for a maximum of 10 acres of land. This is partly due to inadequate resourcing. The Myanmar Agricultural Development Bank (MADB) has to ration its loans at a level below that farmers need to apply agricultural inputs effectively. The research found that the existing Government of Myanmar's agriculture programs are less effective in promoting efficient rice production, especially for larger-scale farms, in the three regions selected for the study. The findings for farm households with holdings 8-12 acres of land, however, strongly argue for the impact of subsidized credit scheme on rice production and rice income and total income. The results for the interval between 0-20 and 5-15 acres show the positive spillover effect on farm other income activities. The key results suggest that the MADB could not meet its objectives, which is to help improve rice productivity, particularly for large farm households.

The findings of the third essay show the effect of household demographic characteristics, cultivated land size and asset ownership on income diversification in the selected regions. This essay found that many farmers, particularly those from lower-income households, would be more productive if they had better skills and knowledge of farming practices. Due to the insignificant impact of regional effects, this study also analysed the determinants of income diversification in each region. The findings for the total agricultural land size are significantly robust in Ayeyarwaddy and Bago Regions. Farm households with holdings of large amounts of land have less motivation to diversify their income by participating in different activities. The effect of distance to market on income diversification differs between regions. The results for the Delta Region (Ayeyarwaddy and Bago) show the negative effect of distance to market on diversification, while the findings for the Dry Zone show little impact on diversifying income. The results of the Gini coefficient reveal that diversifying crops in Bago and Sagaing, and engaging in breeding livestock in the three regions, are important factors in decreasing income inequality. The income from non-farm activities has little impact on income inequality in the three regions.

Based on the findings in this study, the Department of Agriculture (DOA) should deliver better training to farmers, so that farmers can use their resources more efficiently and effectively. Funding constraints also likely contribute to inadequate irrigation and other support infrastructure that could improve farm yields, and reduce transportation cost. The government should improve its planning and investment in agricultural infrastructure, in particular, rural road construction and the development of irrigation facilities. These recommendations are supported by the experience of Vietnam's efforts to boost its own rice production, which show that using better quality seed, effective use of fertilizer and better irrigation facilities can lead to a dramatic improvement in rice production. There is a need for the Department of Agricultural Research (DAR) and the Department of Agriculture (DOA) to implement improved research that helps develop the production and distribution of better quality seed. The government should also encourage the private sector to invest in the agriculture sector, especially in the rural credit market, where the MADB mainly provides credits at a subsidized interest rate.

Unfortunately for this study, not enough time has lapsed since the introduction of Myanmar's 2012 Farmland Law to evaluate its effect on rice production. In particular, the land use certificates were only partially implemented at the time the field research was undertaken. These reforms are expected to provide farmers in Myanmar with more incentive to improve rice productivity. It is recommended that the effect of these reforms on agricultural productivity be studied after sufficient time has passed for these effects to be measurable. Furthermore, the importance of a cost and benefit analysis for both rice and non-rice crops should be interest for further research, which can provide a clear pattern of the profits from both rice and other cash crops that can help improve rural income in the selected regions.

Appendix A

Sampling Frame

A.1 Sampling procedure for the Myanmar Rice Farm Survey 2014

This appendix describes the sampling procedure used for the Myanmar Rice Farm Survey (MRFS) in 2014. In this survey, 634 farms were interviewed in 30 villages which are located in six townships in three most rice producing regions.

A.1.1 Background

The administrative structure of Myanmar should be taken into account to set up the sampling framework. The structure of country includes five levels as:.

- The first level: Myanmar is divided into 15 States and Regions.
- The second level: these states and divisions are divided into 67 districts.
- The third level: the districts are divided into 330 townships.
- The fourth level: the townships are divided into 3,183 wards in urban areas and 13,602 village tracks in rural areas.
- The fifth level: village tracts are divided into 70,838 villages.

The 2014 population census in Myanmar indicates that the country has about 51.5 million people, or 10.9 million households, of which about 70 percent live in rural areas.

A.1.2 MRFS 2014 sampling

A stratified multistage cluster sampling method was used for MRFS 2014 to save costs while targeting the population of interest. The three major rice growing regions, in particular, Ayeyarwaddy, Bago and Sagaing, were selected on the basis of regions that produce the most rice, the nature of farming conditions, soil types, types of irrigation systems and crop intensity. The cultivated acres in Ayeyarwaddy, Bago and Sagaing account for 27 per cent, 11 per cent and 10 per cent of the whole country respectively. Ayeyarwaddy, Bago and Sagaing produce roughly 26 percent, 17 percent and 12 percent, respectively, of the total rice output in Myanmar in 2012-2013 (Agricultural Extension Division, 2013). Apart from the similarity of being key rice producing regions, these three regions differ in soil type which in turn affects their rice production and crop diversity. In particular, while both in the delta, the soil in Ayeyarwady is gley and gley swampy while that in Bago is meadow and meadow alluvial. On the other hand, one township in Sagaing has meadow and meadow alluvial soils while the other has red-brown forest soils.

Ayeyarwady and Bago are located in the Delta Region whereas Sagaing is located in the Central Dry Zone. Regarding population size, Ayeyarwady has about 6 million people while the other regions have, about 5 million each. Regarding administrative divisions, Ayeyarwady consists of six districts, Bago has four, while Sagaing has eight. The district with the highest rice output in each region was selected in the first stage of our sample scheme. The districts include Pyapon in Ayeyarwady, Bago in Bago and Shwebo in Sagaing, being identified as strata in our sample.

In the second stage, two townships were randomly selected from each district. They include Bogalay and Pyapon in Pyapon, Ayeyarwady; Daik-U and Nyaung Lay Pin in Bago; and Wetlet and Kyunhla in Sagaing. A township sampling frame was set up using the Myanmar Health Profile (DHP, 2009). The rural population ('000) was identified as a population variable for township selection. Likewise, in the third stage, five villages were randomly selected in each township. The sampling frame of a village was developed with township-level agricultural officials.

Farm households interviewed in each village in the final stage were chosen using a circular systematic sample method with the probability of being selected proportional to the village's number of farm households. Finally, the sample size was calculated taking into account two factors. The first one was the design effect which has resulted in the loss of sample effectiveness by the use of cluster sampling instead of simple random sampling (Kalton, 1983). With no better information about how big or small this effect is due to the similarity among households being sampled in the same cluster, we use the rule of thumb suggested by the literature to set it equal to 1.5 (e.g. ICF International, 2012; UN, 2008). The second factor is the possible non-response. Following Barlett et al. (2001), our sample size is calculated follows

$$n = \frac{1}{RR} \times DEFF \times \frac{(t_{\alpha/2})^2 \times p \times q}{d^2} = \frac{1}{0.90} \times 1.5 \times \frac{(1.96)^2 \times 0.5 \times 0.5}{0.05^2} \approx 640 \tag{A.1}$$

where RR is the response rate, assumed to be 90%; DEFF is the design effect, set at equal to 1.5; $p \times q$ is the estimate of variance, assuming is equal to $0.5 \times 0.5 = 0.25$; $t_{\alpha/2} = 1.96$ is the statistical value for the level of α equal to 5 percent–the risk the survey accepts in the study that the true margin of error may exceed the acceptable margin of error, and the population size being millions of households in three regions of interest; and d is the acceptable margin of error, set at equal to 0.05 being within the usual range of 0.05-0.1 (Suresh and Chandrashekara, 2012).

Based on the above sample frame and desirable size, I successfully interviewed 634 farms in total in three regions, six townships and 30 villages. The sub-samples for each region are 215 farms in Ayeyarwady, 212 farms in Bago and 207 in Sagaing. Map A.1 illustrates the selected regions and townships. Map A.2, Map A.3 and Map A.4 demonstrate Ayeyarwaddy, Bago and Sagaing regions respectively.

A.1.3 Information in questionnaire

The questionnaire in this survey consisted of five sections. Section A includes the demographic characteristics of farm households such as number of family members, and their gender, age, education level, numbers of years of schooling, marital status, and types of business activity and occupation that they engaged in. In Section B, information regarding the cultivation of rice paddy and other crops for each parcel of land were collected in detail. These include farming experience of the head of household, total areas of plot and the characteristics of each plot, the irrigation facilities and their quality, the status of land tenure and holding land use right certificate. In addition, the details of harvesting for crops, uses of productive resources such as seed, use of fertilizers and pesticides and their prices, and costs of production including family and hired labours, animals, tools, other equipment and machinery during the past 12 months were also included in the survey. The costs of transportation and different types of sales of rice paddy were also added in this section.

In Section C, the provision of agricultural credit form the Myanmar Agricultural Development Bank and other organizations such as UNDP, NGO, PACT, co-operatives and private money lenders, and their interest rates on farm activities were collected. Farmers were also asked the detailed information relating to access to credit. This information included the purpose of borrowing, availability of loans, different types of providers such as formal and informal financial institutions, and interest rates on loans. Section D consists of other expenditures related to farming activities and transportation costs for travelling from home to farmland. The sources of a household's incomes from on-farm activities (cultivation of other crops, livestock and fishery) and non-farm activities (other non-agricultural business activities) are observed in Section E.

Fig. A.1 Myanmar Map

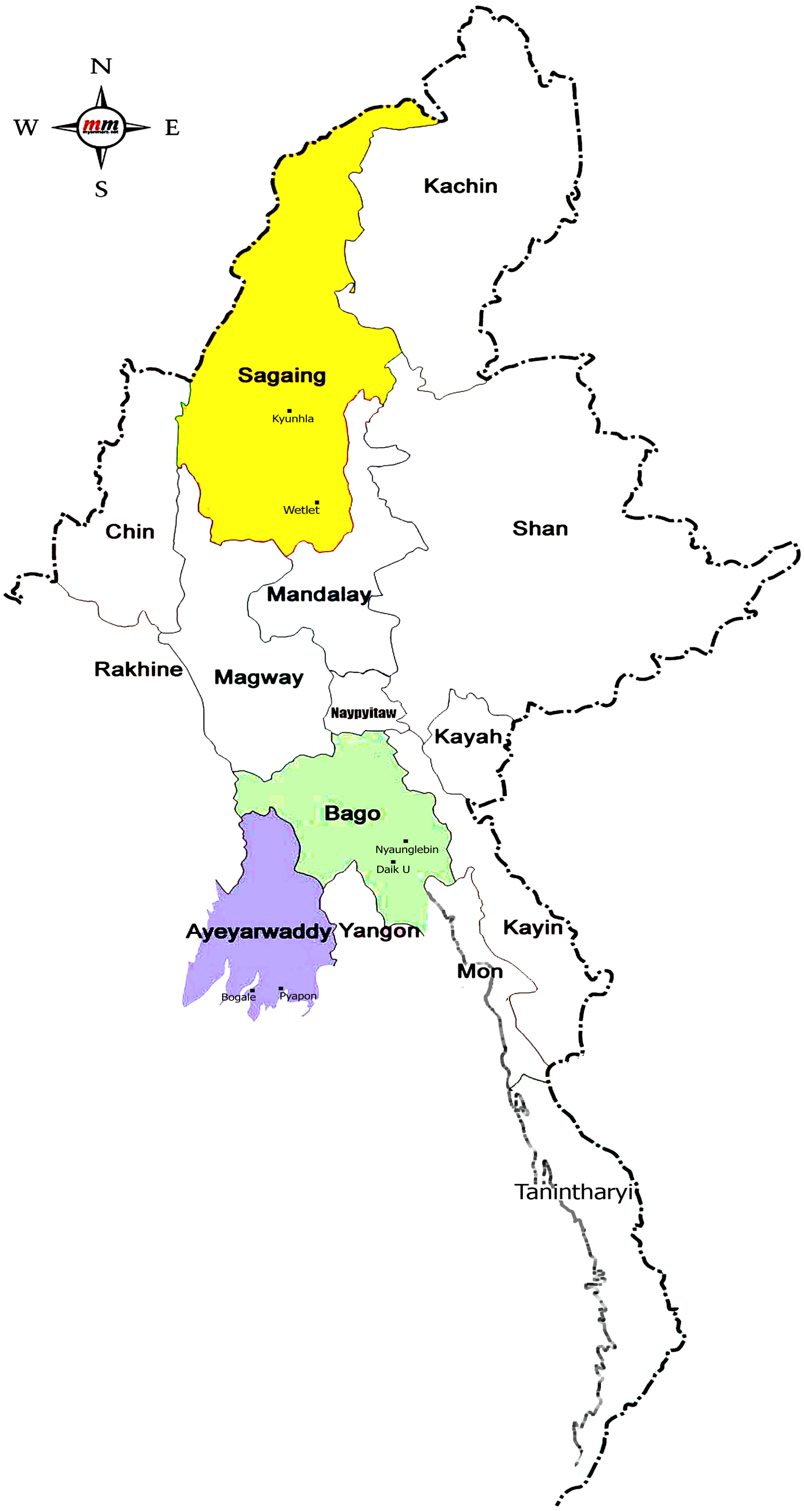
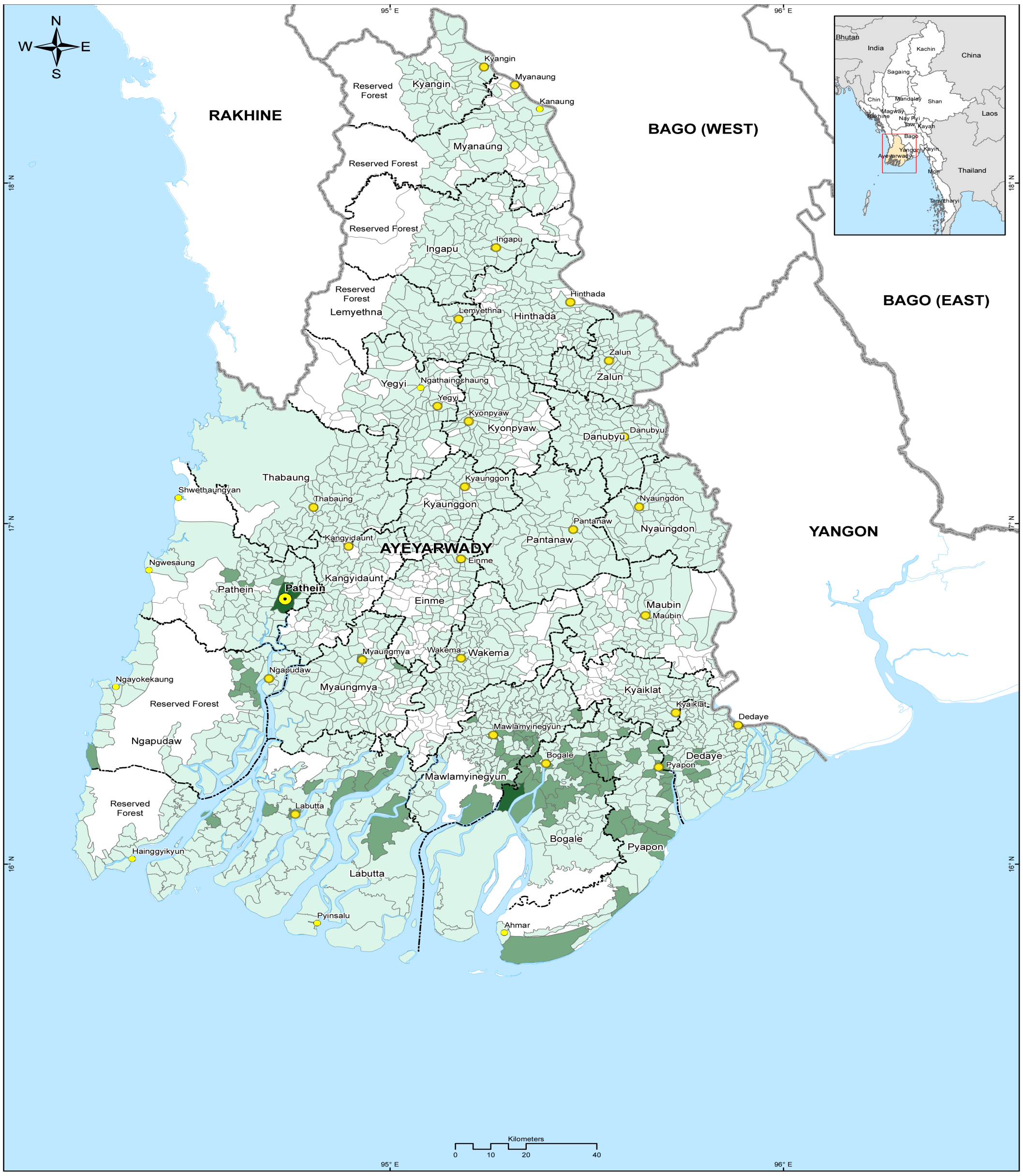
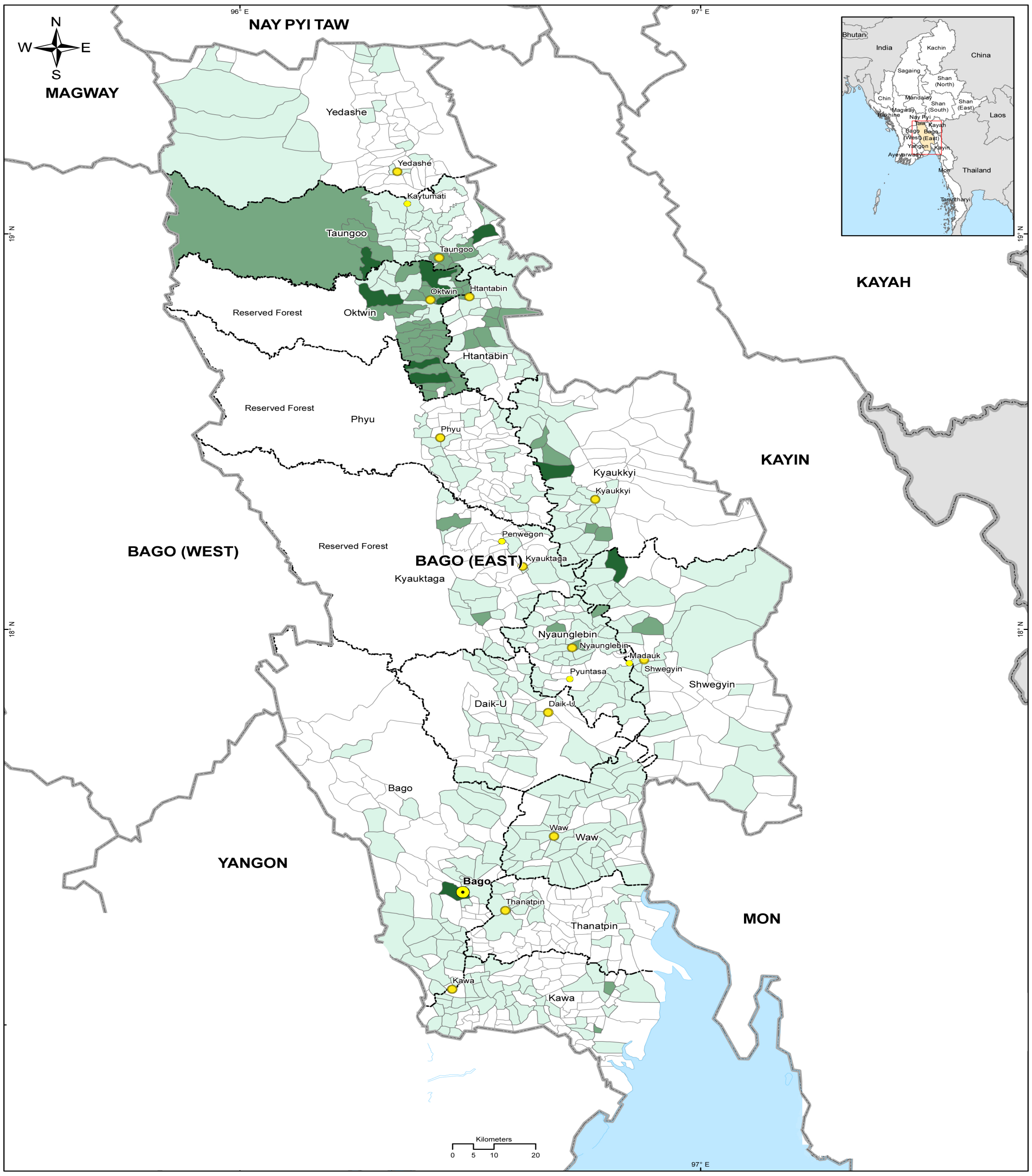


Fig. A.2 Ayeyarwaddy Region



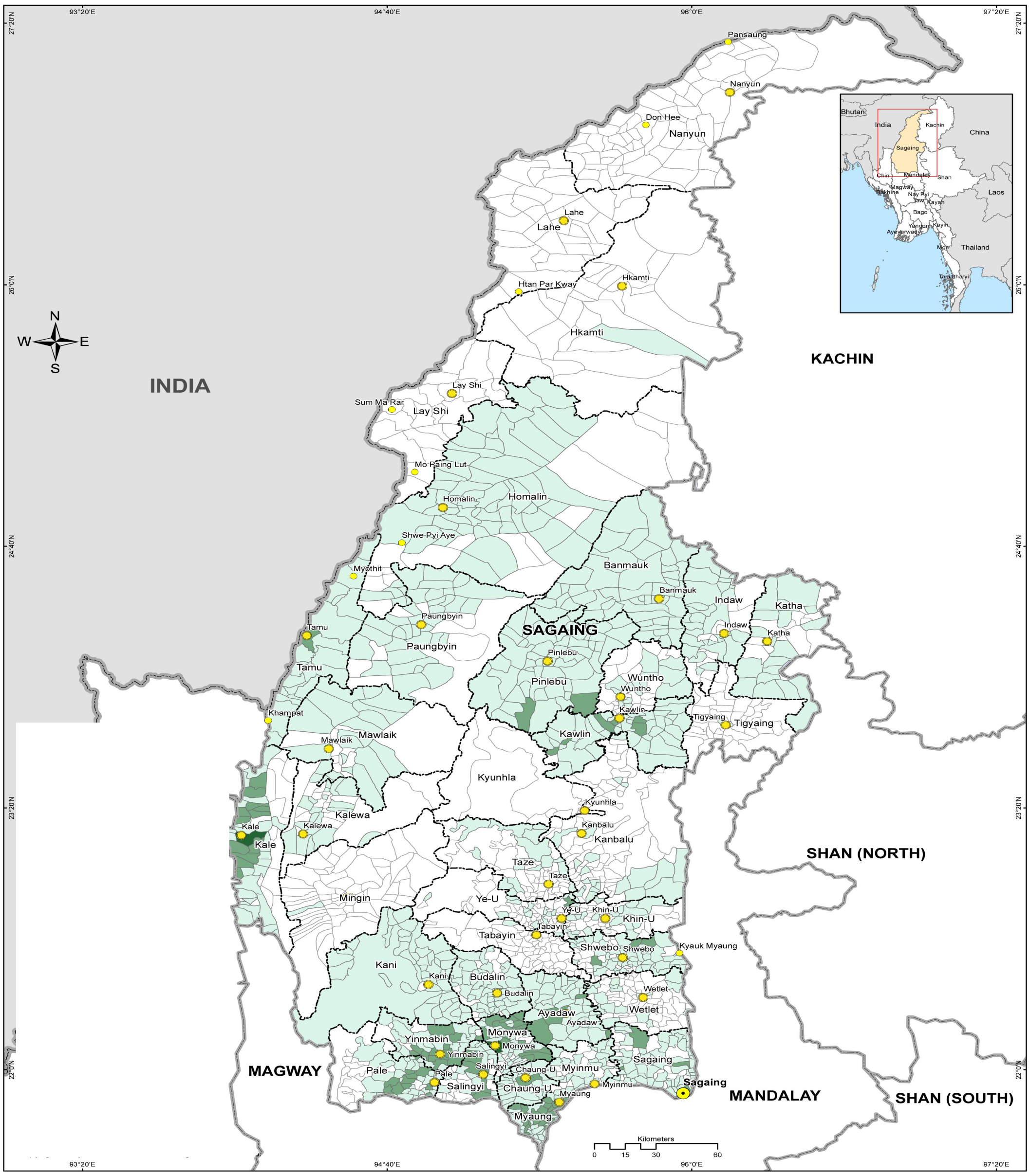
Source: Redrawn from Myanmar Information Management Unit 2016

Fig. A.3 Bago Region



Source: Redrawn from Myanmar Information Management Unit 2016

Fig. A.4 Sagaing Region



Source: Redrawn from Myanmar Information Management Unit 2016

References

Adams, R. H. (1993). Non-farm income and inequality in rural Pakistan. *The Pakistan Development Review*, 32(4):1187–1198.

Adams Jr, R. H. (2002). Nonfarm income, inequality, and land in rural Egypt. *Economic Development and Cultural Change*, 50(2):339–363.

ADB (2012). Myanmar in Transition: Opportunities and Challenges. ADB Reports, Asian Development Bank, Manila.

ADB (2013). Myanmar agriculture, natural resources, and environment initial sector, assessment, strategy, and road map. Technical report, Asian Development Bank, Manila.

Adebayo, C., Akogwu, G., and Yisa, E. (2012). Determinants of Income Diversification among Farm Households in Kaduna State: Application of Tobit Regression Model. *PAT*, 8(2):1–10.

Adebayo, O. and Adeola, R. (2008). Sources and uses of agricultural credit by small scale farmers in Surulere Local Government Area of Oyo State. *Anthropologist*, 10(4):313–314.

Adepoju, A. and Oyewole, O. (2014). Rural livelihood diversification and income inequality in local government area Akinyele, Ibadan, Oyo state, Nigeria. *Journal of Agricultural Sciences, Belgrade*, 59(2):175–186.

Adger, W. N. (1999). Exploring income inequality in rural, coastal Viet Nam. *The Journal of Development Studies*, 35(5):96–119.

Agricultural Extension Division (2013). Annual Report. Technical report, Department of Agriculture, Ministry of Agricultural and Irrigation, Myanmar.

Agyeman, B. A. S., Asuming-Brempong, S., Onumah, E. E., et al. (2014). Determinants of Income Diversification of Farm Households in the Western Region of Ghana. *Quarterly Journal of International Agriculture*, 53(1):55–72.

Aigner, D., Lovell, C. K., and Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *journal of Econometrics*, 6(1):21–37.

Akaakohol, M. A. and Aye, G. C. (2014). Diversification and farm household welfare in Makurdi, Benue State, Nigeria. *Development Studies Research. An Open Access Journal*, 1(1):168–175.

Akinbode, S. O. (2013). Access to credit: Implication for sustainable rice production in Nigeria. *Journal of Sustainable Development in Africa*, 15(1):13–30.

Aktaruzzaman, K. (2013). The Impact of Microcredit in Rural Bangladesh: A Fuzzy Regression Discontinuity Design Approach. *Available at SSRN 2206826*.

Aktaruzzaman, K. and Farooq, O. (2016). Impact of microcredit on borrowers' expenditures: a fuzzy regression discontinuity design approach. *Applied Economics*, pages 1–10.

Akudugu, M. A., Guo, E., and Dadzie, S. K. (2012). Adoption of modern agricultural production technologies by farm households in Ghana: What factors influence their decisions. *Journal of Biology, Agriculture and Healthcare*, 2(3).

Asmah, E. E. (2011). Rural livelihood diversification and agricultural household welfare in Ghana. *Journal of Development and Agricultural Economics*, 3(7):325–334.

Aung, N. M. (2011). Agricultural efficiency of rice farmers in Myanmar: A case study in selected areas. *Institute of Developing Economies Discussion Paper*, (306).

Aung, N. M. (2012). Production and Economic Efficiency of Farmers and Millers in Myanmar Rice Industry. *Institute of Developing Economies Discussion Paper*, (471).

Banerjee, A. V., Duflo, E., Glennerster, R., and Kinnan, C. (2013). The miracle of microfinance? Evidence from a randomized evaluation.

Barker, R., Ringler, C., Nguyen, M. T., and Rosegrant, M. (2004). Macro policies and investment priorities for irrigated agriculture in Vietnam. Technical report, International Water Management Institute.

Barlett, J. E., Kotrlik, J. W., and Higgins, C. C. (2001). Organizational research: Determining appropriate sample size in survey research. *Information technology, learning, and performance journal*, 19(1):43.

Barrett, C. B., Reardon, T., and Webb, P. (2001). Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. *Food policy*, 26(4):315–331.

Battese, G. E. and Coelli, T. J. (1993). *A stochastic frontier production function incorporating a model for technical inefficiency effects*, volume 69. Department of Econometrics, University of New England Armidale.

Battese, G. E. and Coelli, T. J. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical economics*, 20(2):325–332.

Battese, G. E. and Corra, G. S. (1977). Estimation of a production frontier model: with application to the pastoral zone of Eastern Australia. *Australian journal of agricultural economics*, 21(3):169–179.

Baulch, B., Hansen, H., Trung, L. D., and Tam, T. N. M. (2008). The spatial integration of paddy markets in Vietnam. *Journal of Agricultural Economics*, 59(2):271–295.

Behrman, J. R., Sengupta, P., and Todd, P. (2000). The impact of progresa on achievement test scores in the first year. *International Food Policy Research Institute, Washington, DC*.

Cho, K. M. (2013). Background paper no. 5 current situation and future opportunities in agricultural education, research and extension in Myanmar.

Christiaensen, L., Demery, L., and Kuhl, J. (2011). The (evolving) role of agriculture in poverty reduction—an empirical perspective. *Journal of development economics*, 96(2):239–254.

Coelli, T. J. (1996). A guide to frontier version 4.1: a computer program for stochastic frontier production and cost function estimation. Cepa working papers.

Cotula, L. (2009). *Land grab or development opportunity?: agricultural investment and international land deals in Africa*. Iied.

Dapice, D. O., Vallely, T. J., Wilkinson, B., McPherson, M., Kennedy, J., and Montesano, M. (2011). Myanmar agriculture in 2011: Old problems and new challenges. *Ash Center for Democratic Governance and Innovation, Harard Kennedy School*.

David, P., O'Brien, J. P., Yoshikawa, T., and Delios, A. (2010). Do shareholders or stakeholders appropriate the rents from corporate diversification? the influence of ownership structure. *Academy of Management Journal*, 53(3):636–654.

Davis, J. R. (2003). The Rural-Non-Farm Economy, Livelihoods and their Diversification: Issues and Options. *Livelihoods and their Diversification: Issues and Options (July 2003)*.

Dawe, D. (2013). Geographic determinants of rice self-sufficiency in Southeast Asia. *Agricultural Development Economics Division Working Paper*, pages 13–03.

De Luna-Martinez, J. and Anantavrasilpa, R. (2014). Myanmar Agricultural Development Bank: Initial Assessment and Restructuring Options. Initial report, World Bank: Bangkok.

Demissie, A. and Legesse, B. (2013). Determinants of income diversification among rural households: The case of smallholder farmers in Fedis district, Eastern hararghe zone, Ethiopia. *Journal of Development and Agricultural Economics*, 5(3):120–128.

Denning, G., Baroang, K., and Sandar, T. M. (2013). Background Paper No. 2 Rice Productivity Improvement in Myanmar. *Retrieved May*, 30:2014.

Department of Agricultural Planning (2012). Myanmar Agriculture in Breif. Technical report, Department of Agricultural Planning, Ministry of Agricultural and Irrigation, Myanmar.

Department of Agricultural Planning (2013a). Country Statement of Myanmar. Technical report, Department of Agricultural Planning, Ministry of Agricultural and Irrigation, Myanmar.

Department of Agricultural Planning (2013b). Myanmar Agriculture in Breif. Technical report, Department of Agricultural Planning, Ministry of Agricultural and Irrigation, Myanmar.

Department of Agricultural Planning (2014a). Myanmar Agriculture at a Glance. Technical report, Department of Agricultural Planning, Ministry of Agricultural and Irrigation, Myanmar.

Department of Agricultural Planning (2014b). Myanmar Agriculture in Breif. Technical report, Department of Agricultural Planning, Ministry of Agricultural and Irrigation, Myanmar.

Department of Agriculture (2016). Road map for Myanmar's seed sector: 2017-2020. Technical report, Ministry of Agriculture, Livestock and Irrigation, Myanmar.

DeSilva, S. (2011). Access to Markets and Farm Efficiency: A Study of Rice Farms in the Bicol Region, Philippines. *Levy Economics Institute of Bard College Working Paper*, (687).

DHP (2009). Township Health Profile. Department of Health Planning (DHP), Ministry of Health, Union of Myanmar.

Dimova, R. D. and Sen, K. (2010). Is household income diversification a means of survival or a means of accumulation? Panel data evidence from Tanzania. *Panel Data Evidence from Tanzania (April 6, 2010)*.

Duflos, E., Luchtenburg, P., Ren, L., and Chen, L. Y. (2013). Microfinance in Myanmar Sector Assessment. *Washington, DC: International Finance Corporation,[Online] Available at: http://www. cgap. org/publications/microfinance-myanmar-sector-assessment [Accessed: 30/03/2013*.

Dung, N. M. (2014). The seed industry in Vietnam.

Duong, P. B. and Izumida, Y. (2002). Rural development finance in Vietnam: A microeconometric analysis of household surveys. *World Development*, 30(2):319–335.

Duwayri, M., Van Tran, D., et al. (2000). Reflections on yield gaps in rice production: how to narrow the gaps. *RAP Publication (FAO)*.

Duy, V. Q. (2012). The role of access to credit in rice production efficiency of rural households in the Mekong Delta Vietnam. *Center for Asian Studies Discussion Paper*, (284).

Elbers, C. and Lanjouw, P. (2001). Intersectoral transfer, growth, and inequality in rural Ecuador. *World Development*, 29(3):481–496.

Ellis, F. (1998). Household strategies and rural livelihood diversification. *The journal of development studies*, 35(1):1–38.

Ellis, F. (2000a). The determinants of rural livelihood diversification in developing countries. *Journal of Agricultural Economics*, 51(2):289–302.

Ellis, F. (2000b). *Rural livelihoods and diversity in developing countries*. Oxford university press.

Ersado, L. (2006). *Income diversification in Zimbabwe: Welfare implications from urban and rural areas*, volume 3964. World Bank Publications.

Escobal, J. (2001). The determinants of nonfarm income diversification in rural Peru. *World Development*, 29(3):497–508.

FAO (2009). Crop and food security assessment mission to Myanmar. Technical report, Food and Agriculture Organization, Rome.

FAO (2016). Myanmar: National Action Plan for Agriculture (NAPA).

Food Security Working Group (2015). Chemical and organic fertilizer market in relation to the interests of small farmers in Myanmar.

Fujita, K., Mieno, F., and Okamoto, I. (2009). *The economic transition in Myanmar after 1988: Market economy versus state control*, volume 1. NUS Press.

Gamse, B. C., Jacob, R. T., Horst, M., Boulay, B., and Unlu, F. (2008). Reading first impact study. final report. ncee 2009-4038. *National Center for Education Evaluation and Regional Assistance*.

Goletti, F. and Rich, K. (1998). Policy simulation for agricultural diversification, Strengthening capacity for the renewal of rural development in Vietnam (Phase 1) Markets and Structural Studies Division, International Food Policy Research Institute. Technical report, UNDP VIE/96/008/A/01/99 Final Report.

Government of Vietnam (1993). Decree No.64-CP 1993: Regulations on stable and long-term allocation of land to individuals using the long-terms stability in agricultural production. Technical report, Government of Vietnam.

Gregory, D., Shwe, T. M., and Oo, N. (2014). Myanmar Fertilizer Policy Evaluation. Technical report, Increasing Food Security and Agricultural Sustainability.

Guirkinger, C. and Boucher, S. R. (2008). Credit constraints and productivity in Peruvian agriculture. *Agricultural Economics*, 39(3):295–308.

Haggblade, S., Boughton, D., Cho, K. M., Denning, G., Kloeppinger-Todd, R., Oo, Z., Sandar, T. M., Than, T. M., Wai, N. E. M. A., Wilson, S., et al. (2014). Strategic Choices Shaping Agricultural Performance and Food Security in Myanmar. *Journal of International Affairs*, 67(2):55.

Haggblade, S., Boughton, D., et al. (2013). A Strategic Agricultural Sector and Food Security Diagnostic for Myanmar. Technical report, Michigan State University, Department of Agricultural, Food, and Resource Economics.

Hahn, J., Todd, P., and Van der Klaauw, W. (2001). Identification and estimation of treatment effects with a regression-discontinuity design. *Econometrica*, 69(1):201–209.

Hai, L. T. D. et al. (2003). The organization of the liberalized rice market in Vietnam. *Unpublished PhD Thesis, Groningen University, the Netherlands.*

Hannah, L. and Kay, J. A. (1977). *Concentration in modern industry: Theory, measurement and the UK experience.* Springer.

Htoo, T. (2016). Agriculture Ministry requests k 500 billion loan. *Myanmar Times, http://www.mmtimes.com/index.php/business/20390-agriculture-ministry-requests-k500-billion-loan.html [Accessed: 30/05/2016.*

Hudson-Rodd, N., Nyunt, M., Tun, S. T., and Htay, S. (2003). The impact of the confiscation of land, labor, capital assets and forced relocation in Burma by the military regime. *NCUB/FTUB discussion paper. Accessed at http://www. ibiblio. org/obl/docs/land_confiscationcontents. htm on*, 16(12):2005.

ICF International (2012). Demographic and health survey sampling and household listing manual. MEASURE DHS, Calverton, Maryland, USA: ICF International.

Idiong, I. (2007). Estimation of farm level technical efficiency in smallscale swamp rice production in cross river state of Nigeria: a stochastic frontier approach. *World Journal of Agricultural Sciences*, 3(5):653–658.

Ikenwilo, D., Olajide, D., Obemebe, O., Ibeji, N., and Akindola, R. (2016). The impact of a rural microcredit scheme targeting women on household vulnerability and empowerment: Evidence from South West Nigeria.

Imbens, G. W. and Lemieux, T. (2008). Regression discontinuity designs: A guide to practice. *Journal of econometrics*, 142(2):615–635.

Izumida, Y. and Duong, P. B. (2001). Measuring the progress of rural finance in vietnam/le développement de la finance rurale au Vietnam. *Savings and Development*, pages 139–166.

Jacob, R. T., Zhu, P., Somers, M.-A., and Bloom, H. S. (2012). *A practical guide to regression discontinuity.* Citeseer.

Jaffee, S., Dang, K., Nguyen, D., Cassou, E., Truong, T., Nguyen, T., Ambrosio, M., and Larson, D. (2016). Vietnam Development Report 2016: Transforming Vietnamese Agriculture: Gaining More from Less.

Joshi, P. K., Gulati, A., Birthal, P. S., and Tewari, L. (2004). Agriculture diversification in South Asia: patterns, determinants and policy implications. *Economic and Political Weekly*, pages 2457–2467.

Kaino, T. et al. (2005). Rural Credit Markets in Myanmar: A Study of Formal and Non-Formal Lenders. *Asian Journal of Agriculture and Development*, 4(1):3–15.

Kalton, G. (1983). *Introduction to survey sampling*, volume 35. Sage.

Karakaplan, M. U. et al. (2017). Fitting endogenous stochastic frontier models in stata. *Stata Journal*, 17(1):39–55.

Karlan, D. and Zinman, J. (2009). Expanding credit access: Using randomized supply decisions to estimate the impacts. *Review of Financial studies*, page hhp092.

Katchova, A. L. (2005). The farm diversification discount. *American Journal of Agricultural Economics*, 87(4):984–994.

Khatun, D., Roy, B., et al. (2012). Rural livelihood diversification in West Bengal: determinants and constraints. *Agricultural Economics Research Review*, 25(1):115–124.

Kodde, D. A. and Palm, F. C. (1986). Wald criteria for jointly testing equality and inequality restrictions. *Econometrica: journal of the Econometric Society*, pages 1243–1248.

Kompas, T., Che, T. N., Nguyen, H. T. M., and Nguyen, H. Q. (2012). Productivity, net returns, and efficiency: land and market reform in Vietnamese rice production. *Land Economics*, 88(3):478–495.

Kompas, T. et al. (2002). Market reform, productivity and efficiency in Vietnamese rice production.

KPMG (2015). Myanmar's untapped opportunity. Technical report, KPMG Services Pte.Ltd.

Kubo, K. et al. (2013). Rice Yield Gap between Myanmar and Vietnam: A Matter of Price Policy or Public Investment in Technology? *Asian Journal of Agriculture and Development*, 10(1).

Kubo, M., Purevdorj, M., et al. (2004). The future of rice production and consumption. *Journal of Food Distribution Research*, 35(1):128–142.

Kurosaki, T. (2008). Crop choice, farm income, and political control in Myanmar. *Journal of the Asia Pacific Economy*, 13(2):180–203.

Kuwornu, J. K., Bashiru, M., and Dumayiri, M. (2014). Farm Households' Livelihood Diversification into Agro-processing and Non-agro-processing Activities: Empirical Evidence from Ghana. *Information Management and Business Review*, 6(4):191.

Kyaw, D. (2009). *Rural Household's Food Security Status and Coping: Strategies to Food Insecurity in Myanmar.* Institute of Developing Economies, Japan External Trade Organization.

Kyi, T. and von Oppen, M. (1999). *An Economic Analysis of Technical Efficiency of Rice Farmers at the Delta Region in Myanmar.* Universität Hohenheim. Institut für Agrar-und Sozialökonomie in den Tropen und Subtropen.

Lanjouw, P., Murgai, R., and Stern, N. (2013). Nonfarm diversification, poverty, economic mobility, and income inequality: a case study in village India. *Agricultural Economics*, 44(4-5):461–473.

Lee, D. S. (2008). Randomized experiments from non-random selection in US house elections. *Journal of Econometrics*, 142(2):675–697.

Lee, D. S. and Lemieux, T. (2009). Regression discontinuity designs in economics. Technical report, National Bureau of Economic Research.

Lee, D. S. and Lemieux, T. (2010). Regression Discontinuity Designs in Economics. *Journal of Economic Literature*, 48:281–355.

Lemieux, T. and Milligan, K. (2008). Incentive effects of social assistance: A regression discontinuity approach. *Journal of Econometrics*, 142(2):807–828.

Lerman, R. I. and Yitzhaki, S. (1985). Income inequality effects by income source: a new approach and applications to the United States. *The review of economics and statistics*, pages 151–156.

Li, X., Gan, C., and Hu, B. (2011). Accessibility to microcredit by Chinese rural households. *Journal of Asian Economics*, 22(3):235–246.

LIFT (2012). Baseline Survey Results. Technical report, Livelihoods and Food Security Trust Fund.

López-Feldman, A. et al. (2006). Decomposing inequality and obtaining marginal effects. *Stata Journal*, 6(1):106–111.

Lwin, H. Y., Myint, T., Than, S., Aung, N. M., San, C. C., and Htut, T. (2014). Role of fertilizers policy in transforming agriculture of Myanmar. ReSAKSS Policy Note 1. Technical report, International Food Policy Research Institute (IFPRI), USA.

Marsh, S. P., MacAulay, T. G., Hung, P., et al. (2006). Agricultural development and land policy in Vietnam. *Agricultural development and land policy in Vietnam.*

Meeusen, W. and Van den Broeck, J. (1977). Efficiency estimation from Cobb-Douglas production functions with composed error. *International economic review*, pages 435–444.

Mehta, A. (2002). The economics and feasibility of electricity generation using manure digesters on small and mid-size dairy farms. *Available at SSRN.*

Men, N. T. et al. (1995). Vietnamese agriculture in a centrally planned economy and in the transition to a market economy. Technical report, International Institute of Social Studies of Erasmus University Rotterdam (ISS), The Hague.

Meng, L. (2013). Evaluating China's poverty alleviation program: A regression discontinuity approach. *Journal of Public Economics*, 101:1–11.

Ministry of Agricultural and Irrigation (2015). Myanmar rice sector development strategy. Technical report, Ministry of Agricultural and Irrigation, Myanmar.

Minot, N. (2006). *Income diversification and poverty in the Northern Uplands of Vietnam*, volume 145. Intl Food Policy Res Inst.

Minot, N. and Goletti, F. (2000). *Rice market liberalization and poverty in Viet Nam*, volume 114. Intl Food Policy Res Inst.

Mishra, A., El-Osta, H., and Gillespie, J. M. (2009). Effect of agricultural policy on regional income inequality among farm households. *Journal of Policy Modeling*, 31(3):325–340.

Mishra, A. K., Erickson, K. W., Harris, J. M., Hallahan, C. B., Uematsu, H., et al. (2010). Determinants of farm household income diversification in the United States: Evidence from farm-level data. In *Annual Meeting of AAEA, Denver, USA*.

MOALI (2018). Myanmar Agriculture Development Strategy and Investment Plan (2018/19- 2022/23).

Mundlak, Y. (1978). On the pooling of time series and cross section data. *Econometrica: journal of the Econometric Society*, pages 69–85.

Mutter, R. L., Greene, W. H., Spector, W., Rosko, M. D., and Mukamel, D. B. (2013). Investigating the impact of endogeneity on inefficiency estimates in the application of stochastic frontier analysis to nursing homes. *Journal of Productivity Analysis*, 39(2):101–110.

Myanmar Development Resource Institute and Michigan State University (2013). Strategic Choices for the Future of Agriculture in Myanmar. Technical report, USAID.

Myint, P. and Napasintuwong, O. (2016). Economic Analysis of paw san rice adoption in Myanmar. *Asian Journal of Agricultural Research*, 10(5):175–184.

Myint, T. and Kyi, T. (2005). Analysis of technical efficiency of irrigated rice production system in Myanmar. In *Proceedings of conference on international agricultural research for development, Stuttgart-Hohenheim, Germany*.

Naing, T., Kingsbury, A., Buerkert, A., and Finckh, M. R. (2008). A survey of Myanmar rice production and constraints. *Journal of Agriculture and Rural Development in the Tropics and Subtropics (JARTS)*, 109(2):151–168.

Nan Wutyi, S., Abdlatif, I., bin MOHAMED, Z. A., et al. (2013). Farm Efficiency and Socioeconomic Determinants of Rain-Fed Rice Production in Myanmar: A Non-Parametric Approach. *Asian Journal of Empirical Research*, 3(11):1401–1413.

Nugent, J. B. and Walther, R. J. (1982). Short-run changes in rural income inequality: A decomposition analysis. *The Journal of Development Studies*, 18(2):239–269.

Odaka, K. (2015). *The Myanmar Economy: Its Past, Present and Prospects*. Springer.

OECD (2014). OECD investment policy reviews: Myanmar 2014. Technical report, OECD.

Okamoto, I. (2005). Transformation of the rice marketing system and Myanmar's transition to a market economy.

Okamoto, I. (2008). *Economic disparity in rural Myanmar: transformation under market liberalization*. NUS Press.

Okamoto, I., Kurita, K., Kurosaki, T., and Fujita, K. (2003). Rich Periphery, Poor Center: Myanmar's Rural Economy under Partial Transition to Market Economy. Technical report, mimeo, Institute of Economic Research, Hitotsubashi University, October.

Oluwatayo, I. B. (2009). Poverty and income diversification among households in rural Nigeria: A gender analysis of livelihood patterns. In *The 2nd Instituto de EstudosSociais e Económicos (IESE) Conference on 'Dynamics of Poverty and Patterns of Economic Accumulation in Mozambique*, pages 22–23.

Omondi, S. O. and Shikuku, K. M. (2013). An analysis of technical efficiency of rice farmers in ahero irrigation scheme,Kenya. *Journal of Economics and Sustainable Development*, 4(10):1–12.

Oo, T. H. and Kudo, T. (2003). *Agro-Based Industry in Myanmar: prospects and challenges*. Institute of Developing Economies, Japan External Trade Organization.

Oo, T. H. and Shwe, T. M. (2015). Role of seed in transforming of agriculture in Myanmar.

Pellegrini, L. and Tasciotti, L. (2014). Crop diversification, dietary diversity and agricultural income: empirical evidence from eight developing countries. *Canadian Journal of Development Studies/Revue canadienne d'études du développement*, 35(2):211–227.

Phan, T., Bilgin, A., Eyland, A., Shaw, P., et al. (2004). Literacy in Vietnam—an atlas. *Hanoi, Vietnam. Asia-Pacific Research Institute Macquarie University, Australia*.

Ponce, J. and Bedi, A. S. (2010). The impact of a cash transfer program on cognitive achievement: The Bono de Desarrollo Humano of Ecuador. *Economics of Education Review*, 29(1):116–125.

Pyatt, G., Chen, C.-N., and Fei, J. (1980). The distribution of income by factor components. *The quarterly journal of economics*, pages 451–473.

Rahman, K., Mia, M., and Bhuiyan, M. (2012). A stochastic frontier approach to model technical efficiency of rice farmers in Bangladesh: an empirical analysis. *The Agriculturists*, 10(2):9–19.

Rahman, S., Umar, H., et al. (2009). Measurement of technical efficiency and Its determinants in crop production in Lafia Local Government Area of Nasarawa State, Nigeria. *Journal of Tropical Agriculture, Food, Environment and Extension*, 8(2):90–96.

Raitzer, D., Wong, L. C., and Samson, J. N. (2015). Myanmar's Agriculture Sector: Unlocking the Potential for Inclusive Growth. *Asian Development Bank Economics Working Paper Series*, (470).

Reardon, T., Delgado, C., and Matlon, P. (1992). Determinants and effects of income diversification amongst farm households in Burkina Faso. *The Journal of Development Studies*, 28(2):264–296.

Robinson, I., Mukhalla, E., Beraki, Y., Mwinga, B., and Odero, A. (2008). FAO/WFP crop and food security assessment mission to southern Sudan. Special report. *Special Reports and Alerts (FAO)*.

Sarah, A. (2012). Determinants of Rural Household Income Diversification in Senegal and Kenya. *Lund University (Sweden)*.

Sawaneh, M., Latif, I. A., and Abdullah, A. M. (2013). Analysis of Rice Production Instability in Southeast Asian Countries. *Asian Journal of Agriculture and Rural Development*, 3(10):688.

Schneider, K. and Gugerty, M. K. (2011). Agricultural productivity and poverty reduction: Linkages and pathways. *Libraries Test Journal*, 1(1):56–74.

Senadza, B. (2011). Does non-farm income improve or worsen income inequality? Evidence from rural Ghana. *African Review of Economics and Finance*, 2(2):104–121.

Shorrocks, A. F. (1982). Inequality decomposition by factor components. *Econometrica: Journal of the Econometric Society*, pages 193–211.

Shwe, T. M. and Hlaing, T. C. (2011). Scoping Study on Food Security and Nutrition Information in Myanmar, National Consultant's Report. Technical report, Food and Agriculture Organization.

Sibiko, K. W., Owuor, G., Birachi, E., Gido, E., Ayuya, O., and Mwangi, J. (2013). Analysis of determinants of productivity and technical efficiency among smallholder common bean farmers in eastern Uganda. *Current Research Journal of Economic Theory*, 5(3):44–55.

Small, L. E. (1996). Irrigation operation and maintenance in Vietnam under economic restructuring. *Irrigation and Drainage Systems*, 10(3):245–262.

Soe, A. and Kyi, T. (2016). Overview of Irrigation Development and Government Policy in Myanmar.

Soe, T. et al. (2004). Myanmar in economic transition: Constraints and related issues affecting the agriculture sector. *Asian Journal of Agriculture and Development*, 1(2):57–68.

Soe, T. and Fisher, B. S. (1990). An Economic Analysis of Burmese Rice Price Policies. *Myanmar Dilemmas and Options, Institute of Southeast Asian Studies: Singapore*, pages 117–166.

Sriboonchitta, S. and Wiboonpongse, A. (2000). Analysis of Technical Efficiency and the Effect of Neck Blast on Jasmine Rice Production Using Stochastic Frontier. *Chiang Mai University Journal of Economics*, 2:39–52.

Staff, W. B. (1994). *World development report 1994: Infrastructure for development*. Oxford University Press, Incorporated.

Stark, O., Taylor, J. E., and Yitzhaki, S. (1986). Remittances and inequality. *The economic journal*, 96(383):722–740.

Steinberg, D. I. (1981). *Burma's road toward development: growth and ideology under military rule*. Westview Press: Boulder, Colorado.

Sujithkumar, P. (2007). Livelihood Diversification: A Case Study in Rural Tamil Nadu. *The Indian Journal of Labour Economics*, 50(4).

Suresh, K. and Chandrashekara, S. (2012). Sample size estimation and power analysis for clinical research studies. *Journal of Human Reproductive Sciences*, 5(1):7.

Tang, S.-Y. (1995). Informal credit markets and economic development in Taiwan. *World Development*, 23(5):845–855.

Than, K. M. (2011). A study of literature reviews on farmer education and farm efficiency. *Yangon University of Distance Education Research Journal*, 3(1):145–151.

Thangata, P. and Mequaninte, T. (2011). The Impact of Agricultural Extension Services on Farm Household Efficiency in Ethiopia.

Thein, M. (2004). *Economic development of Myanmar*. Institute of Southeast Asian Studies.

Thi Ut, T. and Kajisa, K. (2006). The impact of green revolution on rice production in Vietnam. *The Developing Economies*, 44(2):167–189.

Thistlethwaite, D. L. and Campbell, D. T. (1960). Regression-discontinuity analysis: An alternative to the ex post facto experiment. *Journal of Educational psychology*, 51(6):309.

Thomas, F., Om, K., San, T., and Sophie, W. (2015). Myanmar's financial sector: A challenging environment. Technical report, GIZ.

Tracey-White, J. (2005). *Rural-urban marketing linkages: an infrastructure identification and survey guide*, volume 161. Food & Agriculture Org.

Tran Toan Thang (2014). Fertilizers in Vietnam. ReSAKSS Policy Note 11. Technical report, International Food Policy Research Institute (IFPRI), USA.

UN (2008). Designing Household Survey Samples: Practical Guidelines. Statistics Division, Department of Economic and Social Affairs, United Nations: New York.

UNHCR (2011). Guidance note on land issues: Myanmar. Technical report, UNHCR.

USDA (2018). Gain and Feed Annual. Technical report, USDA Foreign Agricultural Service.

VAN, N. P. H., NGA, T. T., ARAI, H., HOSEN, Y., CHIEM, N. H., and INUBUSHI, K. (2014). Rice straw management by farmers in a triple rice production system in the Mekong Delta, Viet Nam. *Tropical Agriculture and Development*, 58(4):155–162.

Van den Broek, J., Subedi, A., Jongeleen, F., and Oo, N. L. (2015). Pathways for the developing Myanmar's seed sector: A scoping study. Technical report, Centre for Development Innovation, Wageningen UR.

Van der Klaauw, W. (2002). Estimating the effect of financial aid offers on college enrollment: A Regression–Discontinuity Approach. *International Economic Review*, 43(4):1249–1287.

Velarde, O., Pede, V., et al. (2013). Pattern of investment allocation to chemical inputs and technical efficiency: A stochastic frontier analysis of farm households in Laguna, Philippines. In *2013 Conference (57th), February 5-8, 2013, Sydney, Australia*, number 152203. Australian Agricultural and Resource Economics Society.

Wan, G. H. and Cheng, E. (2001). Effects of land fragmentation and returns to scale in the Chinese farming sector. *Applied Economics*, 33(2):183–194.

Weldegebriel, Z. B., Folloni, G., and Prowse, M. (2015). The Determinants of Non-Farm Income Diversification in Rural Ethiopia. *Journal of Poverty Alleviation & International Development*, 6(1).

Win, N. (2013). Experiences of Myanmar Agricultural Development Bank program on value chain finance on agriculture. Technical report, Asia-Pacific Rural and Agricultural Credit Association.

Win, U. K. (1991). *A century of rice improvement in Burma*. Int. Rice Res. Inst.

Winters, P., Davis, B., Carletto, G., Covarrubias, K., Quiñones, E. J., Zezza, A., Azzarri, C., and Stamoulis, K. (2009). Assets, activities and rural income generation: evidence from a multicountry analysis. *World Development*, 37(9):1435–1452.

Wong, L. C. and Wai, E. M. A. (2013). Background Paper No. 6 Rapid Value Chain Assessment: Structure and Dynamics of the Rice Value Chain in Myanmar.

World Bank (1974). Agricultural Development and Credit in the Union of Burma. Report No. 454a-BA, World Bank.

World Bank (2012). Revising the Land Law to Enable Sustainable Development in Vietnam. World Bank Other Operational Studies 26777.

World Bank (2014). Myanmar: Capitalizing on rice export opportunities. Technical report, World Bank Group, Washington DC.

World Bank (2015). World Development Indicator. Technical report, World Bank, viewed 25 May 2015, http://data.worldbank.org/indicator/AG.CON.FERT.ZS.

Yakub, A., Samon, E. K., Perdanan, W. A., Yanny, I., Mi, Y., and Kim, K. (2012). Revisiting Vietnam rice farming: Moving towards industralization.

Young, K. B., Wailes, E., and Cramer, G. L. (1998). An economic assessment of the Myanmar rice sector: current developments and prospects.

Zaw, K., Lwin, N., Nyein, K. T., and Thandar, M. (2011). Agricultural Transformations, Institutional Changes and Rural Development in Ayeyarwady Delta, Myanmar. *Agricultural Development, Trade and Regional Cooperation in Developing East Asia*.

Zhao, J. and Barry, P. J. (2014). Income diversification of rural households in China. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie*, 62(3):307–324.

Zorya, S. (2016). Unleashing Myanmar's agricultural potential. Technical report, World Bank, 27 May 2016, http://blogs.worldbank.org/eastasiapacific/unleashing-myanmar-agricultural-potential.